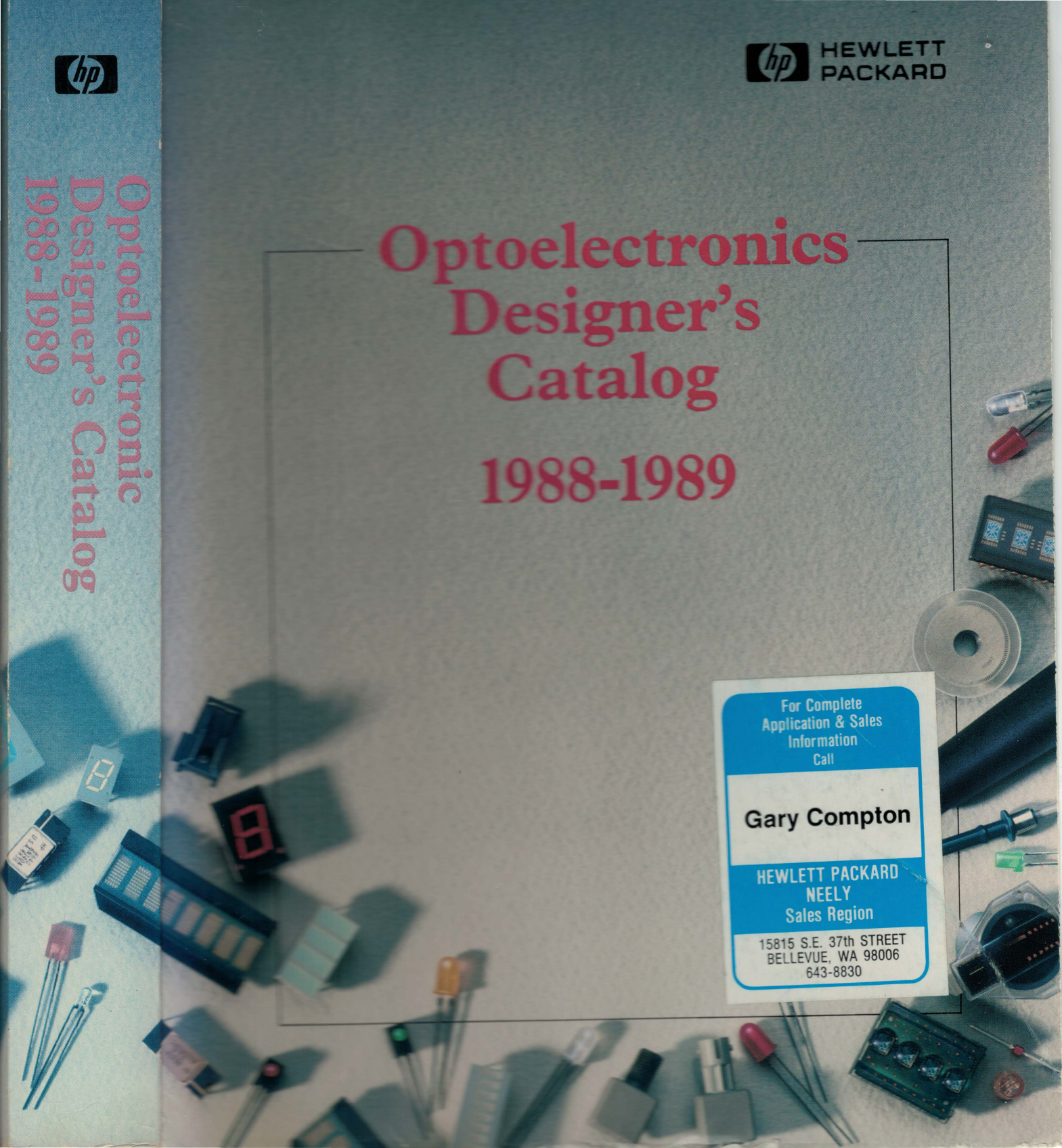
Optoelectronic Designer's Catalog 1988-1989

HEWLETT PACKARD

Optoelectronics Designer's Catalog

1988-1989



For Complete Application & Sales Information Call

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Optoelectronics Designer's Catalog

To help you choose and design with Hewlett-Packard optoelectronic components, this catalog includes detailed specifications for HP component products. The products are divided into nine sections:

- High Reliability
- Ink-Jet Components
- Bar Code Components
- Motion Sensing and Encoder Products
- LED Light Bars and Bar Graph Arrays
- LED Lamps
- LED Displays
- Fiber Optics
- Optocouplers

How to Find the Right Information

The Table of Contents (pp. iii) indicates each of the nine sections listed above by a thumb-tab. An alphanumeric index (pp. iv) follows the Table of Contents, and it lists every component represented in this catalog.

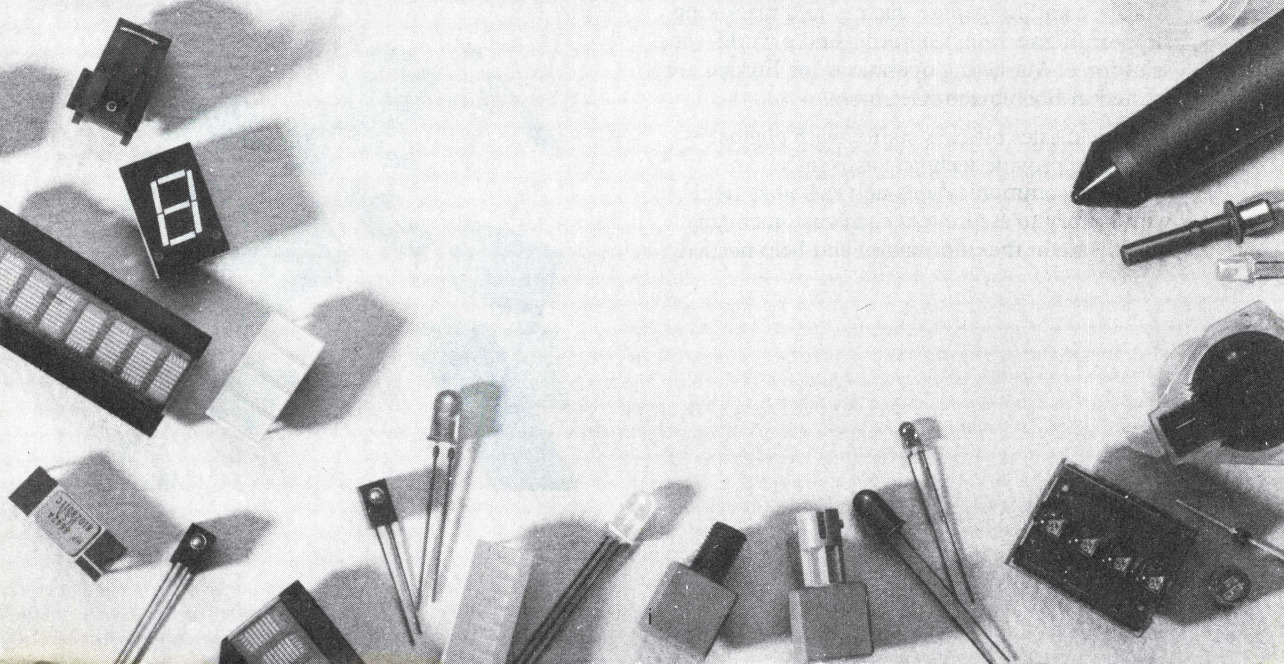
At the beginning of each of the nine product sections, there is a selection guide with basic product specifications which allows you to quickly select products most suitable for your application.

Following the product sections is a complete listing of application bulletins and notes which are frequently useful as design aids. The final section is an appendix containing HP sales, service, and authorized distributor locations.

How to Order

To order any component in this catalog or additional applications information, call the HP office nearest you and ask for the Components representative. A complete listing of the U.S. sales offices is on pp. 11-13; offices located outside of the U.S. are listed on pp. 11-6.

A world-wide listing of HP authorized distributors is on pp. 11-2. These distributors can offer off-the-shelf delivery for most HP components.



Hewlett-Packard Components: A Brief Sketch

History

In 1964, Hewlett-Packard established a new division having the charter of developing and producing state-of-the-art electronic components for internal use. By 1975, both microwave and optoelectronic devices contributed to the growing business of Hewlett-Packard and the Components Group was formed. Today there are three divisions: the Optoelectronics division, Optical Communications division and Microwave Semiconductor division. In addition to these three divisions there is a specialized team of people to develop, manufacture and market bar code components.

The products of the Components Group are vertically integrated, from the growing of LED crystals to the development of the various on-board integrated circuits to package design. Vertical integration insures that HP quality is maintained throughout product development and manufacturing.

Over 5000 employees are dedicated to HP Components, including manufacturing facilities in Malaysia and Singapore, factory and marketing support in San Jose, California and a world-wide sales force. Marketing operations for Europe are located in Boeblingen, Germany.

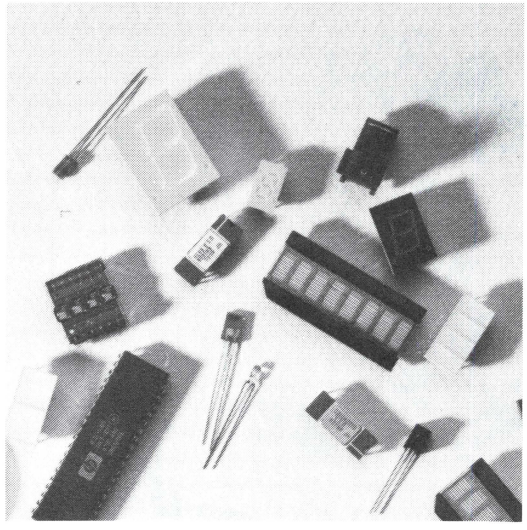
Each field sales office is staffed with engineers trained to provide technical assistance. An extensive communications network links field with factory to assure that each customer can quickly attain the information and help needed.

Quality and Reliability

Quality and reliability are two very important concepts to Hewlett-Packard in maintaining the commitment to product performance.

At Hewlett-Packard, quality is integral to product development, manufacturing and final introduction. "Parts per million" (PPM) as a measure of quality is used in HP's definition of product assurance. And HP's commitment to quality means that there is a continuous process of improvement and tightening of quality standards. Manufacturing quality circles and quality testing programs are important ingredients in HP products.

Reliability testing is also required for the introduction of new HP components. Lifespan calculations in "mean-time-between-failure" (MTBF) terms are published and available as reliability data sheets. HP's stringent reliability testing assures long component lifetimes and consistent product performance.



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New Products in **BOLD** Type.

High Reliability

- Screening Programs
- Hermetic Lamps Selection Guide
- Hermetic Displays Selection Guide
- Hermetic Optocouplers Selection Guide

High Reliability

Hewlett-Packard has supplied specially tested high reliability optoelectronic products since 1968 for use in state-of-the-art commercial, military, and aerospace applications. To meet the requirements of high reliability, products must be designed with rugged capabilities to withstand severe levels of environmental stress and exposure without failure. We have accomplished this objective by designing a unique family of hermetic products including lamps, displays, and optocouplers which have proven their merits in numerous advanced space and defense programs in the international marketplace.

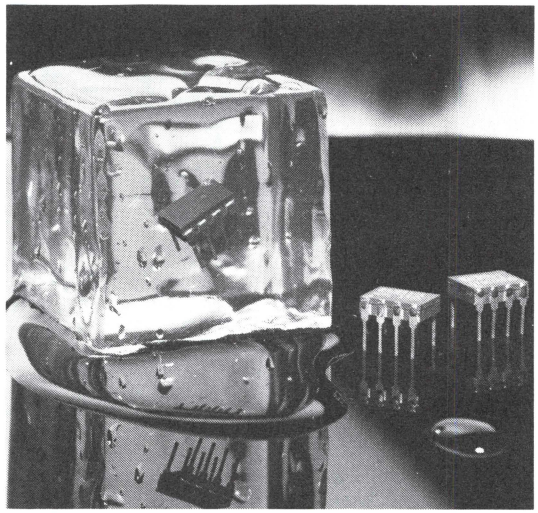
These products receive reliability screening and qualification tests in accordance with the following appropriate reliability programs: MIL-S-19500, MIL-D-87157 and MIL-STD-883. HP supplies JAN and JANTX LED indicators and optocouplers in compliance with DESC selected item drawings and parts with HP standard military equipment screening programs for optocouplers and displays. In addition, Hewlett-Packard optocouplers are considered hybrid devices and are therefore line certified in accordance with MIL-STD-1772, as well as in conformance to Appendices A and G of MIL-M-38510.

Reliability programs are also performed to individual customer control drawings and specifications when needed. Some of these special testing programs are very complex and may include Class S requirements for microcircuits.

HP's epoxy encapsulated optoelectronic products are designed for long life applications where non-man rated or ground support requirements allow their use. As with hermetic products, the capabilities of epoxy parts can be enhanced by 100% screening and conditioning tests. Lot capabilities can be confirmed by acceptance qualfication test programs. MIL-D-87157 is used to define the military requirements for plastic LED indicators and displays.

All testing is done by experienced Hewlett-Packard employees using facilities which are approved by DESC for JAN products and by customer inspection for special programs. Environmental equipment capabilities and operating methods of the test laboratory meet MIL-STD-750 or MIL-STD-883 procedures.

Hewlett-Packard Quality Systems are in compliance with MIL-Q-9858 or MIL-I-45208. The requirements of MIL-STD-45662 are followed by Hewlett-Packard Calibration Systems.



High Reliability Optoelectronic Products

Hewlett-Packard offers the broadest line of high reliability, solid state display products. They are specially designed to withstand severe environmental stresses and exposure without failure. This unique product group includes lamps, integrated numeric and hexadecimal displays, 5 x 7 dot matrix displays, and fully intelligent monolithic 16 segment displays.

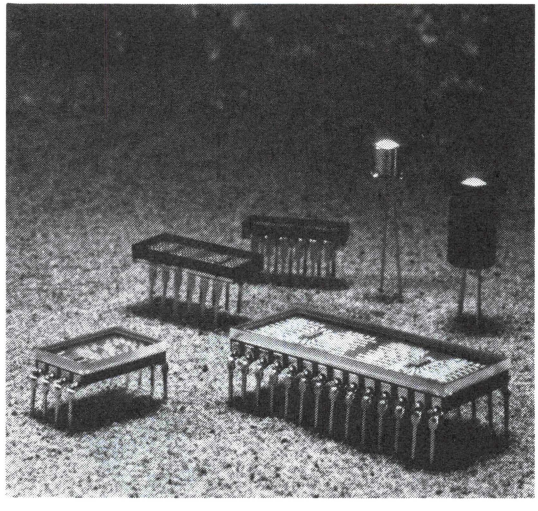
The hermetic solid state lamps are listed on the MIL-S-19500 Qualified Parts List (QPL). These devices meet JAN and JANTX quality levels and are furnished in the basic lamp configuration or an integral panel mountable assembly. Four colors are available: high efficiency red, standard red, yellow and green. The hermetic Ultra-bright lamps are provided with JAN and JANTX equivalent testing. These devices are sunlight viewable and are available in three colors: high efficiency red, yellow and green.

The hermetically sealed 4N51-4N54 hexadecimal and numeric displays are listed on the MIL-D-87157 Qualified Parts List and are supplied to Quality Level A. Four types of devices are available: numeric indicators with right-hand or left-hand decimals, hexadecimal indicator and overrange display with right-hand decimal.

In addition to the QPL products, Hewlett-Packard also offers two in-house high reliability testing programs, TXV and TXVB. The TXVB program conforms to MIL-D-87157 Quality Level A test tables with 100% screening and Quality Conformance Inspection testing (QCI). The TXV program is a modification to Level A testing and consists of 100% screening and Group A testing. Products that are tested to TXV and TXVB programs and comply with MIL-D-87157 hermeticity requirements include the numeric and hexadecimal displays, 5 x 7 dot matrix displays, and monolithic 16 segment displays. Detailed testing programs for these devices are given in the individual data sheets.

The integrated numeric and hexadecimal displays with on board decoder/driver and memory are hermetically sealed and have a character height of 7.4 mm (0.29 inch). These devices are available in standard red; low power, high efficiency red; high brightness, high efficiency red; yellow; and a green epoxy sealed unit that conforms to MIL-D-87157 hermeticity requirements. These devices are designed and tested for use in military and aerospace applications.

The 5 x 7 dot matrix alphanumeric displays with extended temperature range capabilities are available in three character heights: 3.8 mm (0.15 inch), 5 mm (0.2 inch) and 6.9 mm (0.27 inch). These displays are available in several colors: standard red, high efficiency red and yellow. Green devices conforming to MIL-D-87157 hermeticity requirements are available in the 3.8 mm (0.15 inch) and 5 mm (0.2 inch) character heights. The 5 mm (0.2 inch) and 6.9 mm (0.27 inch) versions have the added features of having a solder-glass seal and an even wider operating temperature range than the 3.8 mm (0.15 inch) package. This wide variety of character heights and colors makes these products ideal for a variety of applications in avionics, industrial controls, and instrumentations.

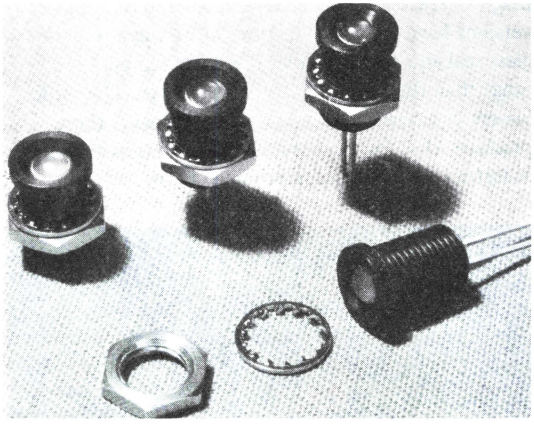


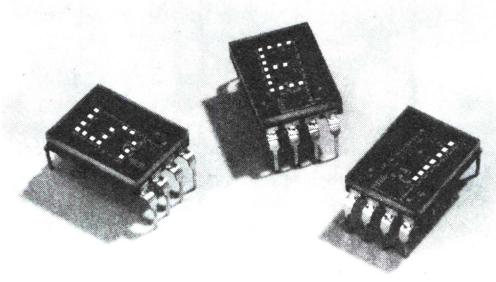
Optoelectronic Product Qualification

DESC Qualified Products

Two military general specifications are presently in use to qualify visible products. MIL-S-19500 establishes the qualification requirements for JAN and JANTX hermetic lamps. Four hermetic lamps and three panel mountable hermetic lamps are listed on the MIL-S-19500 Qualified Parts List (QPL). Descriptions of the individual devices and test program are given in the slash (detail) specifications MIL-S-19500/467, /519, /520 and/521.

MIL-D-87157 establishes the qualification requirements for the 4N51-4N54 light emitting displays. These four hermetic displays are listed on the MIL-D-87157 Qualified Parts List. Descriptions of the individual devices and test program are given in the slash specification MIL-D-87157/1 (ER).





Hewlett-Packard Hi-Rel Testing Programs

By conforming to the requirements of MIL-D-87157 for all other display and lamp products, not discussed above, Hewlett-Packard is able to offer products of significant value to reliability oriented customers. MIL-D-87157 has provisions for four different quality levels as follows:

Level A Hermetic displays with 100% screening and Group A, B and C testing.

Level B Hermetically sealed displays with Group A, B, and C testing and without 100% screening.

Level C Non-hermetic displays with 100% screening and Group A, B and C testing.

Level D Non-hermetic displays with Group A, B, and C testing and without 100% screening.

Hewlett-Packard devices meeting the hermeticity requirements of MIL-D-87157 include the hermetic hexadecimal, numeric and alphanumeric displays described in this section of the catalog. If the suffix TXVB is added to the part number, the display is tested to Level A with 100% screening and qualification tests. When the suffix TXV is added. the devices are submitted to 100% screening and Group A testing.

Detailed testing programs which follow the MIL-D-87157 Quality Level A test tables are given in the individual data sheets. The general MIL-D-87157 Quality Level C program for non-hermetic displays is given on the following pages.

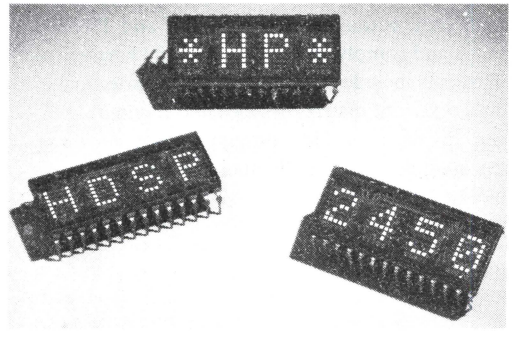


TABLE I. 100% SCREEN FORMAT FOR QUALITY LEVEL C

Test Screen	MIL-STD-750 Method	Level C
1. Precap Visual[1]	2072	When specified
2. High Temperature Storage[1]	1032	100%
3. Temperature Cycling[1]	1051	100%
4. Constant Acceleration[1,2]	2006	When specified
5. Fine Leak[1]	1071	N/A
6. Gross Leak[1]	1071	N/A
7. Interim Electrical/Optical Tests[1]	—	When specified
8. Burn-In[1,3]	1015	100%
9. Final Electrical/Optical Tests	—	100%
10. Delta Determinations[1]	—	When specified
11. External Visual[3]	2009	100%

Notes:
1. These tests are design dependent. The conditions and limits shall be specified in the detail specification when these tests are applicable.
2. Applicable to cavity type displays only.
3. MIL-STD-883 test method applies.

TABLE II. GROUP A ELECTRICAL TESTS[1]

Subgroups	LTPD
Subgroup 1 DC Electrical Tests at 25°C	5
Subgroup 2 Selected DC Electrical Tests at High Temperatures	7
Subgroup 3 Selected DC Electrical Tests at Low Temperatures	7
Subgroup 4 Dynamic Electrical Tests at $T_A = 25°C$	5
Subgroup 5 Dynamic Electrical Tests at High Temperatures	7
Subgroup 6 Dynamic Electrical Tests at Low Temperatures	7
Subgroup 7 Optical and Functional Tests at 25°C	5
Subgroup 8 External Visual	7

Notes:
1. The specific parameters to be included for tests in each subgroup shall be as specified in the applicable detail specification.

TABLE IIIa. GROUP B, CLASS A AND B OF MIL-D-87157 (CLASS C AND D DISPLAYS ONLY)

Test	MIL-STD-750 Method	Sampling Plan
Subgroup 1		
Resistance to Solvents[1]	1022	4 Devices/ 0 Failures
Internal Visual and Design Verification[2, 5, 6]	2075[7]	1 Device/ 0 Failures
Subgroup 2[3,4]		
Solderability[1]	2026	LTPD = 15
Electrical/Optical Endpoints[1]		
Subgroup 3		
Thermal Shock[1] (Temperature Cycling)	1051	LTPD = 15
Moisture Resistance[1]	1021	
Electrical/Optical Endpoints[1]		
Subgroup 4		
Operating Life Test (340 Hours)[1]	1027	LTPD = 10
Electrical/Optical Endpoints[1]		
Subgroup 5		
Non-Operating (Storage) Life Test (340 Hours)[1]	1032	LTPD = 10
Electrical/Optical Endpoints[1]		

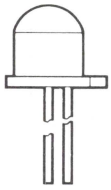
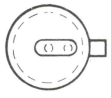
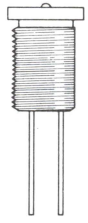
Notes:
1. Test method or conditions in accordance with detail specification.
2. Not required for solid encapsulated displays.
3. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
4. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
5. MIL-STD-883 test method applies.
6. Visual inspection is performed through the window display.
7. Equivalent to MIL-STD-883, Method 2014.

TABLE IVa. GROUP C, CLASS A AND B OF MIL-D-87157

Test	MIL-STD-750 Method	Sampling Plan
Subgroup 1[1]		
Physical Dimensions	2066	2 Devices/ 0 Failures
Subgroup 2[1]		
Lead Integrity[6]	2004	LTPD = 15
Subgroup 3		
Shock[2]	2016	LTPD = 15
Vibration, Variable Frequency[2]	2056	
Constant Acceleration[2]	2006	
External Visual[3]	1010 or 1011	
Electrical/Optical Endpoints[4]		
Subgroup 4		
Operating Life Test[4,5]	1026	$\lambda = 10$
Electrical/Optical Endpoints[4]		
Subgroup 5		
Temperature Cycling (25 cycles min.)[4]	1051	LTPD = 20
Electrical/Optical Endpoints[4]		

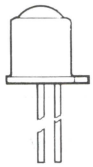
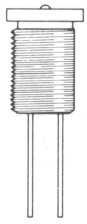
Notes
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. Not required for solid encapsulated displays.
3. Visual requirements shall be as specified in MIL-STD-883, method 1010 or 1011.
4. Test method or conditions in accordance with detail specification.
5. If a given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1000 hours in order to satisfy the Group C life test requirements. In such cases, either the 340 hour endpoint measurements shall be made as a basis for Group B lot acceptance or the 1000 hours endpoint measurements shall be used as the basis for both Group B and C acceptance.
6. MIL-STD-883 test method applies.

Hermetically Sealed and High Reliability LED Lamps

Device		Description			Typical Luminous Intensity	2θ 1/2[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	1N5765 JAN1N5765[4] JANTX1N5765[4]	Red (640 nm)	Hermetic/ TO-46[3]	Red Diffused	1.0 mcd @ 20 mA	70°	1.6 V @ 20 mA	6-146
	1N6092 JAN1N6092[4] JANTX1N6092[4]	High Efficiency Red (626 nm)			5.0 mcd @ 20 mA		2.0 V @ 20 mA	
	1N6093 JAN1N6093[4] JANTX1N6093[4]	Yellow (585 nm)		Yellow Diffused				
	1N6094 JAN1N6094[4] JANTX1N6094[4]	Green (572 nm)		Green Diffused	3.0 mcd @ 25 mA		2.1 V @ 25 mA	
	HLMP-0904 HLMP-0930 HLMP-0931	Red (640 nm)	Panel Mount Version	Red Diffused	1.0 mcd @ 20 mA		1.6 V @ 20 mA	
	HLMP-0354 JANM19500/ 51901[4] JTXM19500/ 51902[4]	High Efficiency Red (626 nm)			5.0 mcd @ 20 mA		2.0 V @ 20 mA	
	HLMP-0454 JANM19500/ 52001[4] JTXM19500/ 52002[4]	Yellow (585 nm)		Yellow Diffused				
	HLMP-0554 JANM19500/ 52101[4] JTXM19500/ 52102[4]	Green (572 nm)		Green Diffused	3.0 mcd @ 25 mA		2.1 V @ 25 mA	

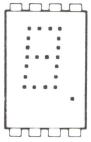
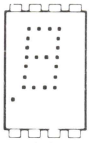
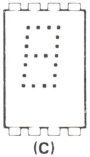
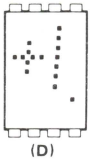
NOTES:
1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. Dominant Wavelength.
3. PC Board Mountable.
4. Military Approved and qualified for High Reliability Applications.

Hermetically Sealed and High Reliability LED Lamps (cont.)

Device		Description			Typical Luminous Intensity	2θ 1/2[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-0363 HLMP-0391 HLMP-0392	High Efficiency Red (626 nm)	Hermetic TO-18[3]	Clear Class	50 mcd @20 mA	18	2.0 V @ 20 mA	6-152
	HLMP-0463 HLMP-0491 HLMP-0492	Yellow (585 nm)			50 mcd @ 20 mA		2.0 V @ 20 mA	
	HLMP-0563 HLMP-0591 HLMP-0592	Green (572 nm)			50 mcd @ 25 mA		2.1 V @ 25 mA	
	HLMP-0364 HLMP-0365 HLMP-0366	High Efficiency Red (626 nm)	Panel Mount Version	Clear Glass	50 mcd @ 20 mA		2.0 V @ 20 mA	
	HLMP-0464 HLMP-0465 HLMP-0466	Yellow (585 nm)			50 mcd @ 25 mA		2.0 V @ 20 mA	
	HLMP-0564 HLMP-0565 HLMP-0566	Green (572 nm)			50 mcd @ 25 mA		2.1 V @ 25 mA	

NOTES:
1. θ1/2 is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. Dominant Wavelength.
3. PC Board Mountable.

Hermetic Hexadecimal and Numeric Dot Matrix Displays

Device		Description	Package	Application	Page No.
 (A)	4N51 4N51TXV M87157/00101ACX[1] (4N51TXVB) (A)	Numeric RHDP Decoder/Driver/Memory TXV — Hi Rel Screened	8 Pin Hermetic Built-in 15.2 mm (.6") DIP with gold plated leads	• Military High Reliability Applications • Avionics/Space Flight Systems • Fire Control Systems • Ground Support, Shipboard Equipment	7-182
 (B)	4N52 4N52TXV M87157/00102ACX[1] (4N52TXVB) (B)	Numeric LHDP Built-in Decoder/Driver/Memory TXV — Hi Rel Screened			
	4N54 4N54TXV M87157/00103ACX[1] (4N54TXVB) (C)	Hexadecimal Built-in Decoder/Driver/Memory TXV — Hi Rel Screened			
 (C)	4N53 4N53TXV 104ACX[1] (4N53TXVB) (D)	Character Plus/Minus Sign TXV — Hi Rel Screened			
 (D)	HDSP-0781 (A) HDSP-0781 TXV HDSP-0781 TXVB	Numeric RHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Efficiency Red, Low Power	• Ground, Airborne, Shipboard Equipment • Fire Control Systems • Space Flight Systems • Other High Reliability Uses	7-190
	HDSP-0782 (B) HDSP-0782 TXV HDSP-0782 TXVB	Numeric LHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
7.4 mm (.29") 4 x 7 Single Digit Package: 8 Pin Glass Ceramic 15.2mm (.6") DIP Truly Hermetic	HDSP-0783 (D) HDSP-0783 TXV HDSP-0783 TXVB	Overrange ±1 TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0784 (C) HDSP-0784 TXV HDSP-0784 TXVB	Hexadecimal, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0791 (A) HDSP-0791 TXV HDSP-0791 TXVB	Numeric RHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Efficiency Red, High Brightness	• Ground, Airborne, Shipboard Equipment • Fire Control Systems • Space Flight Systems • Other High Reliability Uses	
	HDSP-0792 (B) HDSP-0792 TXV HDSP-0792 TXVB	Numeric LHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			

[1] Military Approved and Qualified for High Reliability Applications.

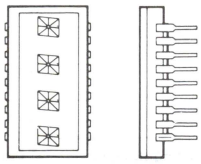
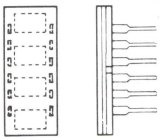
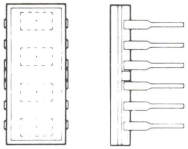
Hermetic Hexadecimal and Numeric Dot Matrix Displays (continued)

Device		Description	Color	Application	Page No.
(See previous page)	HDSP-0783 (D) HDSP-0783 TXV HDSP-0783 TXVB	Overrange ±1 TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Efficiency Red. High Brightness	• Ground, Airborne, Shipboard Equipment • Fire Control Systems • Space Flight Systems • Other High Reliability Uses	7-190
	HDSP-0794 (C) HDSP-0794 TXV HDSP-0794 TXVB	Hexadecimal, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0881 (A) HDSP-0881 TXV HDSP-0881 TXVB	Numeric RHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	Yellow		
	HDSP-0882 (B) HDSP-0882 TXV HDSP-0882 TXVB	Numeric LHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0883 (D) HDSP-0883 TXV HDSP-0883 TXVB	Overrange ±1 TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0884 (C) HDSP-0884 TXV HDSP-0884 TXVB	Hexadecimal, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
(See previous page)	HDSP-0981 (A) HDSP-0981 TXV HDSP-0981 TXVB	Numeric RHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Performance Green		
	HDSP-0982 (B) HDSP-0982 TXV HDSP-0982 TXVB	Numeric LHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0983 (C) HDSP-0983 TXV HDSP-0983 TXVB	Overrange ±1 TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			

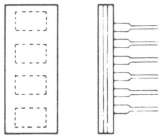
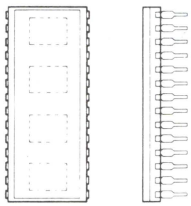
Hermetic Hexadecimal and Numeric Dot Matrix Displays (continued)

Device		Description	Color	Application	Page No.
(See previous page)	HDSP-0984 (D) HDSP-0984 TXV HDSP-0984 TXVB	Hexadecimal, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Performance Green	• Ground, Airborne, Shipboard Equipment • Fire Control Systems • Space Flight Systems • Other High Reliability Uses	7-190

Hermetic Alphanumeric Displays

Device		Description	Color	Application	Page No.
	HMDL-2416 HMDL-2416 TXV HMDL-2416 TXVB	4.1 mm (0.16") Four Character Monolithic Smart Alphanumeric Display Operating Temperature Range: -55°C to 100°C	Red	• Military Equipment • High Reliability Applications • Military Telecommunications	7-204
	HDSP-2351 HDSP-2351 TXV HDSP-2351 TXVB	4.87 mm (0.19") 5 x 7 Four Character Alphanumeric Sunlight Viewable Display Operating Temperature Range: -55°C to 100°C	Yellow	• Military Avionics • Military Cockpit • Military Ground Support Systems	7-214
	HDSP-2352 HDSP-2352 TXV HDSP-2352 TXVB		High Efficiency Red		
	HDSP-2353 HDSP-2353 TXV HDSP-2353 TXVB		High Performance Green		
	HDSP-2010 HDSP-2010 TXV HDSP-2010 TXVB	3.7 mm (.15") 5 x 7 Four Character Alphanumeric Operating Temperature Range: -40°C to +85°C TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	Red, Red Glass Contrast Filter	• Extended temperature applications requiring high reliability. • I/O Terminals • Avionics For further information see Application Note 1016.	7-198

Hermetic Alphanumeric Displays (continued)

Device		Description	Color	Application	Page No.
	HDSP-2310 HDSP-2310 TXV HDSP-2310 TXVB	5.0 mm (.20") 5 x 7 Four Character Alphanumeric 12 Pin Ceramic 6.35 mm (.25") DIP with untinted glass lens Operating Temperature Range: -55°C to +85°C True Hermetic Seal TXV — Hi Rel Screened TXVB — Hi Rel Screened to Level A MIL-D-87157	Standard Red	• Military Equipment • Avionics • High Rel Industrial Equipment	7-228
	HDSP-2311 HDSP-2311 TXV HDSP-2311 TXVB		Yellow		
	HDSP-2312 HDSP-2312 TXV HDSP-2312 TXVB		High Eff. Red		
	HDSP-2313 HDSP-2313 TXV HDSP-2313 TXVB		High Performance Green		
	HDSP-2450 HDSP-2450 TXV HDSP-2450 TXVB	Operating Temperature Range: -55°C to +85°C 6.9 mm (.27") 5 x 7 Four Character Alphanumeric 28 Pin Ceramic 15.24 mm (.6") DIP True Hermetic Seal TXV — Hi Rel Screened TXVB — Hi Rel Screened to Level A MIL-D-87157	Red	• Military Equipment • High Reliability Applications • Avionics • Ground Support, Cockpit, Shipboard Systems	7-235
	HDSP-2451 HDSP-2451 TXV HDSP-2451 TXVB		Yellow		
	HDSP-2452 HDSP-2452 TXV HDSP-2452 TXVB		High Efficiency Red		
	HDSP-2453 HDSP-2453 TXV HDSP-2453 TXVB		High Performance Green		

Hermetic Optocouplers

Hewlett-Packard has selected several very popular optocoupler types for assembly in our militarized hermetic 8 pin and 16 pin dual in-line packages. These devices offer a wide variety of LED input current levels, speed and current transfer ratio. High performance optocouplers are used in many U.S. and international military, aerospace and high reliability applications.

HP's hermetic optocouplers are classified by the U.S. Department of Defense as hybrid microcircuits and therefore comply with line certification requirements of Mil-Std-1772. DESC* granted HP QML (Qualified Manufacturing Line) status in April of 1987, which allows us to continue the supply of both 883B marked parts and DESC drawing parts. Virtually all of our hermetic optocouplers may be purchased with screening and quality conformance testing in compliance with class level B of Mil-Std-883 as standard catalog parts. Class S tested parts are also available under special testing programs. Parts having DESC* military drawings are 8102801EC and 8302401EC and are also available from stock.

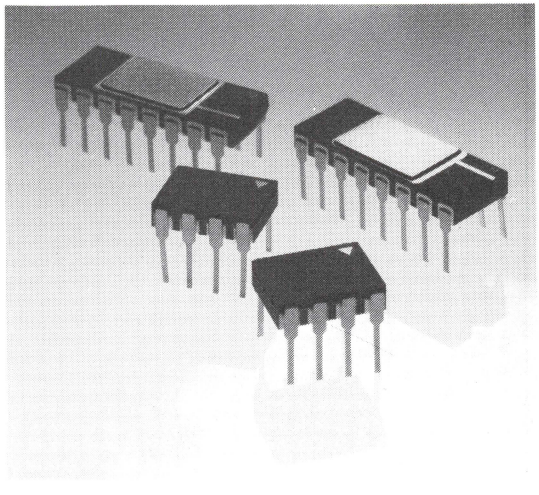
The 8102801EC is a 6N134 consisting of dual channel high speed logic gates compatible with TTL inputs and outputs. The common mode for this part was recently improved to a minimum of 1000 V/μs. A second family of dual channel high speed logic gates, the HCPL-1930/1, also features high common mode and has the added feature of input current regulation. The 8302401EC is a quad channel low input current photo-darlington, ideal for MOS, CMOS, or RS232-C data transmission systems. Finishing out our 16 pin devices is the 4N55 product family. The 4N55 is a dual channel coupler having low gain transistor output useful for isolating circuits in power supply applications, logic interfacing, and wide bandwidth analog applications.

Several years ago, HP commenced the introduction of a new series of 8 pin single and dual channel devices with extraordinary capabilities. The HCPL-5700/1 and HCPL-5730/1 are, respectively, single and dual channel high gain Darlington units. The HCPL-5200/1 and HCPL-5230/1 are high speed logic gate devices with a wide supply voltage from 4.5 to 20 volts and high CMR. The HCPL-5400/1 and HCPL-5430/1 are, respectively, single and dual channel high speed couplers featuring typical data rates of 40 Mbaud. The most recent of our 8 pin hermetic products is the HCPL-5760/1, a single channel, three chip, AC/DC to logic interface optocoupler.**

Our Mil-Std-1772 line certification allows HP to consider assembly and test of more technically advanced hybrid devices where our expertise in materials and processing may contribute to a new product's success in OEM applications. Construction of custom hybrid circuits requires the special working relationship that HP has always enjoyed with its customers toward the advancement of state-of-the-art products.

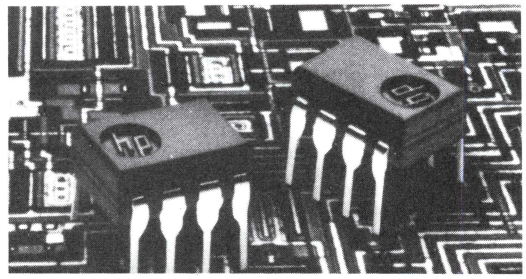
*Defense Electronic Supply Center (DESC) is an agency of the United States Department of Defense (DOD).

**Contact your HP field sales engineer for higher withstand voltage up to 1500 V dc.



Plastic Optocouplers

Hewlett-Packard supplies plastic optocouplers with high reliability testing for commercial/industrial applications requiring prolonged operational life. Two of the most frequently requested 100% preconditioning and screening programs are given. The first program has burn-in and electrical test only, the second program adds temperature storage and temperature cycling. Either program is available for HP's plastic optocouplers. Electrical testing is to catalog conditions and limits and will include 100% DC parameters, sample testing of input-output insulation leakage current and appropriate AC parameters. Contact your local field representative for pricing and availability of these programs.



PLASTIC OPTOCOUPLERS
PRECONDITIONING AND SCREENING 100%

COMMERCIAL BURN-IN*

Examinations or Tests	MIL-STD-883 Methods	Conditions
1. Commercial Burn-in	1015	T_A = 70° C, 160 hours per designated circuit.
2. Electrical Test		Per specified conditions and min./max. limits at T_A = 25° C

SCREENING PROGRAM*

Examinations or Tests	MIL-STD-883 Methods	Conditions
1. High Temperature Storage	1008	24 hours at 125° C
2. Temperature Cycling	1010	10 cycles, -55° C to +125° C
3. Burn-in	1015	T_A = 70° C, 160 hours per designated circuit
4. Electrical Test		Per specified conditions and min./max. limits at T_A = 25° C
5. External Visual	2009	

*Contact your field salesman for details.

GROUP B TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)[1]

Test	Method	Conditions	LTPD
Subgroup 1 Physical Dimensions (Not required if Group D is to be performed)	2016		2 Devices/ 0 Failures
Subgroup 2 Resistance to Solvents	2015		4 Devices/ 0 Failures
Subgroup 3 Solderability (LTPD applies to number of leads inspected — no fewer than 3 devices shall be used.)	2003	Soldering Temperature of 245 ±5° C for 10 seconds	15 (3 Devices)
Subgroup 4 Internal Visual and Mechanical	2014		1 Device/ 0 Failures
Subgroup 5 Bond Strength (1) Thermocompression (performed at precap, prior to seal. LTPD applies to number of bond pulls).	2011	(1) Test Condition D	15
Subgroup 6 Internal water vapor content (Not applicable — per footnote of MIL-STD)	—		—
Subgroup 7 Fine Leak Gross Leak	1014	Test Condition A Test Condition C	5
Subgroup 8* Electrical Test Electrostatic Discharge Sensitivity Electrical Test	3015	Group A, Subgroup 1, except I_{I-O} Group A, Subgroup 1	15

*(To be performed at initial qualification only)

Group C testing is performed on a periodic basis from current manufacturing every 3 months.

GROUP C TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)[1]

Test	Method	Conditions	LTPD
Subgroup 1 Steady State Life Test	1005	Condition B, Time + 1000 Hours Total T_A = +125° C Burn-in conditions are product dependent and are given in the individual device data sheets.	5
Endpoint Electricals at 168 hours and 504 hours		Group A, Subgroup 1, except I_{I-O}	
Endpoint Electricals at 1000 hours		Group A, Subgroup 1 Subgroups 2 and 3 where applicable	
Subgroup 2 Temperature Cycling	1010	Condition C, -65° C to +150° C, 10 cycles	15
Constant Acceleration	2001	Condition A, 5K Gs, Y_1 and Y_2 axis only, 8 pin and 16 pin metal lid DIP Condition E, 30K Gs, Y_1 and Y_2 axis only, 8 pin ceramic lid DIP	
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1010	Per visual criteria of Method 1010	
Endpoint Electricals		Group A, Subgroup 1	

Group D testing is performed on a periodic basis from current manufacturing every 6 months.

GROUP D TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)[1]

Test	Method	Conditions	LTPD
Subgroup 1 Physical Dimensions	2016		15
Subgroup 2 Lead Integrity	2004	Test Condition B2 (lead fatigue)	15
Subgroup 3 Thermal Shock	1011	Condition B, (-55° C to +125° C) 15 cycles min.	15
Temperature Cycling	1010	Condition C, (-65° C to +150° C) 100 cycles min.	
Moisture Resistance	1004		
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination		Per visual criteria of Method 1004 and 1010	
Endpoint Electricals		Group A, Subgroups 1, 2 and 3 where applicable	
Subgroup 4 Mechanical Shock	2002	Condition B, 1500G, t = 0.5 ms, 5 blows in each orientation	15
Vibration Variable Frequency	2007	Condition A min.	
Constant Acceleration	2001	Condition A, 5K Gs, Y_1 and Y_2 axis only, 8 pin and 16 pin metal lid DIP Condition E, 30K Gs, Y_1 and Y_2 axis only, 8 pin ceramic lid DIP	
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1010	Per visual criteria of Method 1010	
Endpoint Electricals		Group A, Subgroups 1, 2 and 3 where applicable	
Subgroup 5 Salt Atmosphere	1009	Condition A min.	15
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1009	Per visual criteria of Method 1009	
Subgroup 6 Internal Water Vapor Content	1018	5,000 ppm maximum water content at 100° C	3 Devices (0 failures) 5 Devices (1 failure)
Subgroup 7 Adhesion of lead finish	2025		15
Subgroup 8 Lid Torque (Applicable to 8 pin ceramic lid DIP only)	2024		5 Devices (0 failures)

Notes:

1. Hewlett-Packard exercises a testing option as allowed by MIL-STD-883, Method 5008, Par. 3.1a. Paragraph 3.1 of Method 5008 states that "hybrid and multichip microcircuits, which are contained in packages having an inner seal perimeter of less than 2.0 inches", may be tested in accordance with the requirements of MIL-STD-883, Methods 5004 and 5005, with a change to the internal visual from Method 2010 to Method 2017.

Hermetic Optocoupler Product Screening and Quality Conformance Test Program (MIL-STD-883 Class B)

The following 100% Screening and Quality Conformance Inspection programs show in detail the capabilities of our hermetic optocouplers. This program will help customers understand the tests included in Methods 5004 and 5005 of MIL-STD-883 and to help in the design of special product drawings where this testing is required. The 4N55/883B, 6N140A/883B, 5231/883B, 1931/883B, 5401/883B, 5201/883B, 5431/883B, 5761/883B, 5701/883B, 5731/883B, 8102801EC and 8302401EC (DESC Selected Item Drawings for the 6N134 and 6N140A respectively) have standardized test programs suitable for product use in military, high reliability applications and are the preferred devices by military contractors. (See note 1.)

100% Screening

MIL-STD-883, METHOD 5004 (CLASS B DEVICES)[1]

Test Screen	Method	Conditions
1. Precap Internal Visual	2017	Condition B, DESC Parts[1]
2. High Temperature Storage	1008	Condition C, T_A = 150° C, Time = 24 Hours minimum
3. Temperature Cycling	1010	Condition C, –65° C to +150° C, 10 cycles
4. Constant Acceleration	2001	Condition A, 5K Gs, Y_1, and Y_2, axis only, 8 pin and 16 pin metal lid DIP Condition E, 30K Gs, Y_1, and Y_2, axis only, 8 pin ceramic lid DIP
5. Fine Leak	1014	Condition A
6. Gross Leak	1014	Condition C
7. Interim Electrical Test	—	Group A, Subgroup 1, except $I_{I/O}$ (optional)
8. Burn-In	1015	Condition B, Time = 160 Hours minimum, T_A = 125° C Burn-in conditions are product dependent and are given in the individual data sheets.
9. Final Electrical Test Electrical Test Electrical Test Electrical Test	—	Group A, Subgroup 1, 5% PDA applies Group A, Subgroup 2 Group A, Subgroup 3 Group A, Subgroup 9
10. External Visual	2009	

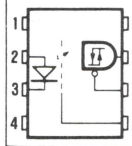
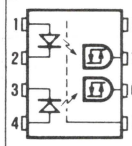
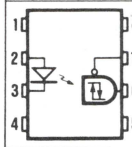
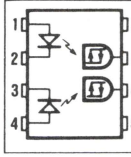
Quality Conformance Inspection

Group A electrical tests are product dependent and are given in the individual device data sheets. Group A and B testing is performed on each inspection lot.

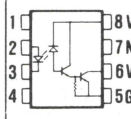
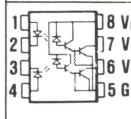
GROUP A TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)[1]

	LTPD
Subgroup 1 Static tests at T_A = 25° C	2
Subgroup 2 Static tests at T_A = +125° C	3
Subgroup 3 Static tests at T_A = –55° C	5
Subgroup 4 Dynamic test at T_A = 25° C (where applicable)	2
Subgroups 5, 6, 7 and 8 These subgroups are non-applicable to this device type	
Subgroup 9 Switching tests at T_A = 25° C	2
Subgroup 10 Switching tests at T_A = +125° C	3
Subgroup 11 Switching tests at T_A = -55° C	5

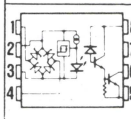
8 Pin Dual-In-Line Package
High-Speed Logic Gate Optocouplers

Device		Description	Application	Typical Data Rate [NRZ]	Common Mode	Specified Input Current	Withstand Test Voltage*	Page No.
	HCPL-5200	Single Channel, Hermetically Sealed Wide Supply Voltage Optocoupler	High Speed Logic Ground Isolation, LSTTL, TTL, CMOS Logic Interface	5 M bit/s	1000 V/μs	6.0 mA	500 Vdc	9-102
	HCPL-5201	MIL-STD-883 Class B	Military/High Reliability					
	HCPL-5230	Dual Channel, Hermetically Sealed Wide Supply Voltage Optocoupler	High Speed Logic Ground Isolation, LSTTL, TTL, CMOS Logic Interface					9-108
	HCPL-5231	MIL-STD-883 Class B Part	Military/High Reliability					
	HCPL-5400	Single Channel Hermetically Sealed High Speed Optocoupler	High Speed Logic Isolation, A/D and Parallel/Serial Conversion	40 M bit/s	500 V/μs	9.0 mA	500 Vdc	9-114
	HCPL-5401	MIL-STD-883 Class B Part	Military/High Reliability					
	HCPL-5430	Dual Channel Hermetically Sealed High Speed Optocoupler	High Speed Logic Isolation, Communications, Networks, Computers					9-120
	HCPL-5431	MIL-STD-883 Class B Part	Military/High Reliability					

High Gain Optocouplers

Device		Description	Application	Typical Data Rate [NRZ]	Current Transfer Ratio	Specified Input Current	Withstand Test Voltage*	Page No.
	HCPL-5700	Single Channel Hermetically Sealed High Gain Optocoupler	Line Receiver, Low Current Ground Isolation, TTL/TTL, LSTTL/TTL, CMOS/TTL	60k bit/s	200% Min.	0.5 mA	500 V dc	9-126
	HCPL-5701	MIL-STD-883 Class B Part	Military/High Reliability					
	HCPL-5730	Dual Channel Hermetically Sealed High Gain Optocoupler	Line Receiver, Polarity Sensing, Low Current Ground Isolation					9-130
	HCPL-5731	MIL-STD-883 Class B Part	Military/High Reliability					

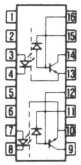
AC/DC to Logic Interface Optocoupler

Device		Description	Application	Typical Data Rate	Input Threshold Current	Output Current	Withstand Test Voltage*	Page No.
	HCPL-5760	Single Channel Hermetically Sealed Threshold Sensing Optocoupler	Limit Switch Sensing, Low Voltage Detector Relay Contact Montitor	10 kHz	2.5 mA TH^+ 1.3 mA TH^-	2.6 mA	500 V dc	9-134
	HCPL-5761	MIL-STD-883 Class B Part	Military/High Reliability					

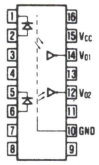
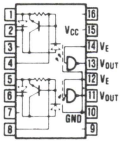
*Contact your HP field sales engineer for higher withstand voltage up to 1500V dc.

16 Pin Dual In-Line Package

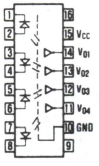
High Speed Transistor Optocouplers

Device		Description	Application	Typical Data Rate (NRZ)	Current Transfer Ratio	Specified Input Current	Withstand Test Voltage	Page No.
	4N55	Dual Channel Hermetically Sealed Analog Optical Coupler	Line Receiver, Analog Signal Ground Isolation, Switching Power Supply Feedback Element	700k bit/s	9% Min.	16 mA	1500 V dc	9-140
	4N55/883B	MIL-STD-883 Class B Part	Military/High Reliability					

High Speed Logic Gate Optocouplers

Device		Description	Application	Typical Data Rate (NRZ)	Common Mode	Specified Input Current	Withstand Test Voltage	Page No.
	6N134	Dual Channel Hermetically Sealed Optically Coupled Logic Gate	Line Receiver, Ground Isolation for High Reliability Systems	10M bit/s	1000 V/μs	10 mA	1500 V dc	9-145
	8102801EC	DESC Approved 6N134	Military/High Reliability					9-149
	HCPL-1930	Dual Channel Hermetically sealed High CMR Line Receiver Optocoupler	Line receiver, High Speed Logic Ground Isolation in High Ground or Induced Noise Environments	10M bit/s	1000 V/μs	10 mA	1500 Vdc	9-153
	HCPL-1931	MIL-STD-883 Class B Part	Military/High Reliability					

High Gain Optocouplers

Device		Description	Application	Typical Data Rate (NRZ)	Current Transfer Ratio	Specified Input Current	Withstand Test Voltage	Page No.
	6N140A (6N140)	Hermetically Sealed Package Containing 4 Low Input Current, High Gain Optocouplers	Line Receiver, Low Power Ground Isolation for High Reliability Systems	100k bit/s	300% Min.	0.5 mA	1500 V dc	9-159
	8302401EC	DESC Approved 6N140A	Military/High Reliability					9-163
	6N140A/883B (6N140/883B)	MIL-STD-883 Class B Part	Use 8302401EC in New Designs					9-159

Ink-Jet Components

- **Thermal Ink-Jet Print Cartridge**
- **Carriage Assembly**

Ink-Jet Products

Thermal Ink-Jet Cartridges

Millions of Hewlett-Packard thermal ink-jet print cartridges have demonstrated their performance and reliability in HP ThinkJet and QuietTel printers. Now this revolutionary, proprietary technology is available for OEM printing devices. Its long list of advantages make it attractive for a wide range of industrial and commercial applications.

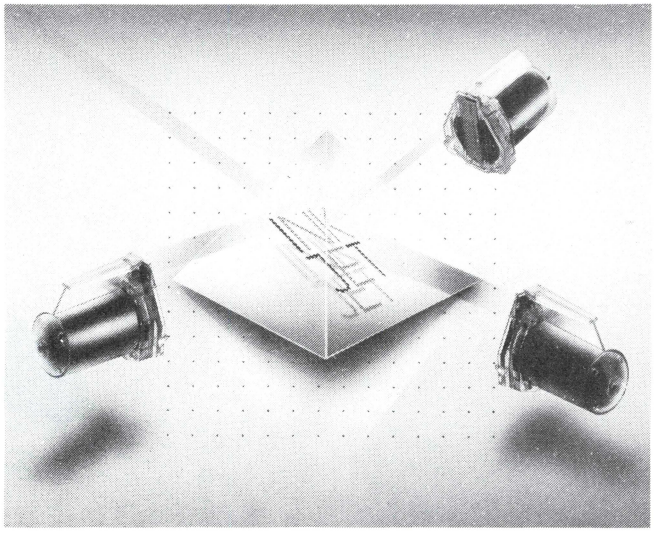
The thumb-sized print cartridges completely integrate all the printing elements and ink supply into a single, *disposable* unit. Reliability is "designed-in", because there are no moving parts, messy ribbons, or complex ink pumps, typical of other printing technologies.

Downtime for ink replenishment or printhead failures is virtually eliminated, because the easy pop-out/drop-in replacement requires no tools or technicians.

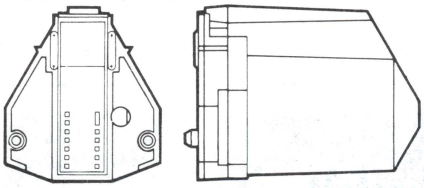
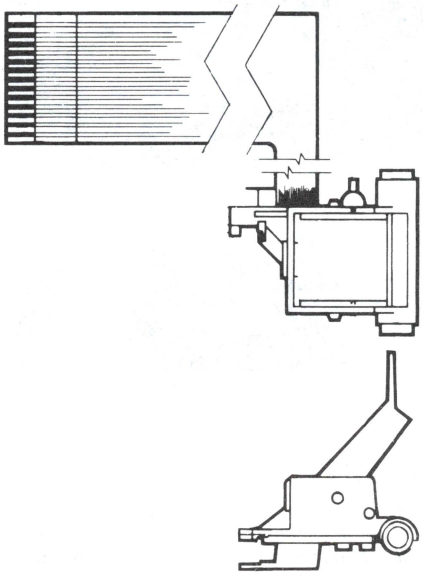
Non-contact printing permits marking on uneven surfaces, a near impossible task for most printing technologies; the silent operation makes the print cartridge especially suitable for office, classroom, and laboratory environments; and the small size and very low power consumption of the print cartridge make it ideal for battery/portable applications.

Among the many applications of this breakthrough technology are: ticketing and receipting machines, point-of-sale devices, printing calculators, medical and scientific recorders, document marking machines, and bar code printers.

To put the printing technology of tomorrow in your products today, look to Hewlett-Packard's thermal ink-jet!



Ink Jet Products

Device				Page No.
Package Outline Drawing	Part No.	Color Ink	Description	
	92261A 51605B 51605R 51605G	Black Blue Red Green	Print cartridges	2-4
	51610A		Carriage Assembly for the Thermal Ink-Jet Print Cartridge	2-8

HEWLETT PACKARD

THERMAL INK-JET PRINT CARTRIDGE

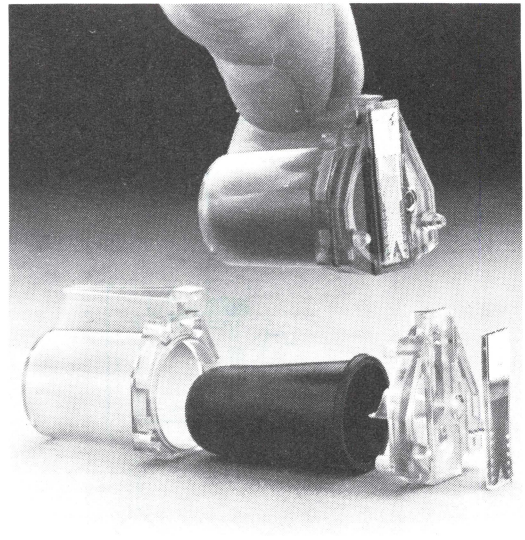
BLACK 92261A
BLUE 51605B
RED 51605R
GREEN 51605G

Features

- HEWLETT-PACKARD'S PROVEN THERMAL INK-JET TECHNOLOGY
- LOW COST DISPOSABLE PRINTHEAD
- HIGH SPEED (1250 DOTS/SEC.)
- HIGH RESOLUTION (96 DOTS/INCH)
- 1/8 INCH PRINT ZONE (12 DOT VERTICALLY IN-LINE)
- 10 MILLION DOT CAPACITY (500K CHARACTERS)
- NON-CONTACT PRINTING
- SMALL SIZE
- VERY LOW POWER CONSUMPTION
- QUIET OPERATION
- EASY REPLACEMENT

Applications

- TICKETING AND RECEIPTING
- PORTABLE PRINTING
- SELECTIVE BAR CODE PRINTING
- INDUSTRIAL AND COMMERCIAL MARKING
- POINT OF SALE PRINTING
- ADDRESSING AND PERSONALIZATION
- SCIENTIFIC AND MEDICAL INSTRUMENTATION
- PERSONAL COMPUTER PRINTING



Description

The HP Thermal Ink-jet print cartridge is a low cost disposable inkjet printhead which is suitable for a broad range of industrial and commercial applications. The totally self-contained print cartridge uses HP's Thermal Ink-jet technology which overcomes the reliability problems of conventional piezoelectric inkjet technologies.

Non-contact printing operation allows printing on irregular surfaces at variable distances. It also eliminates printer failures due to friction wear or foreign body interference. The absence of any moving parts further enhances reliable operation. The self-contained design and pressure interconnect allows fast, simple replacement, and it eliminates the need for any other printer parts such as ribbons, pumps, etc. It can be fired in any physical orientation.

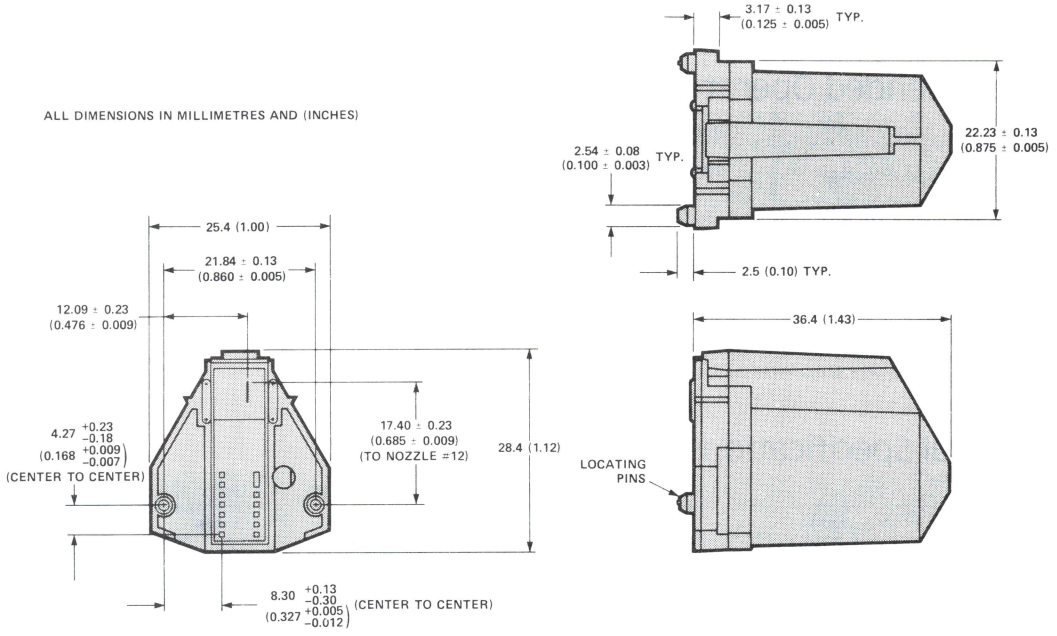
The small size of the print cartridge makes it very suitable for compact or portable printing devices. Its small size also makes it possible to combine several cartridges to provide larger print zones or higher throughput speeds. Virtually silent operation matches the ergonomic needs of the office, classroom and laboratory.

The power consumption of the print cartridge is radically lower than other printing technologies. This dramatically reduces the cost of the printer power supply and driver electronics. It also makes battery operation possible, and lowers radiated EMI levels. Driver circuitry can be made with standard off-the-shelf components.

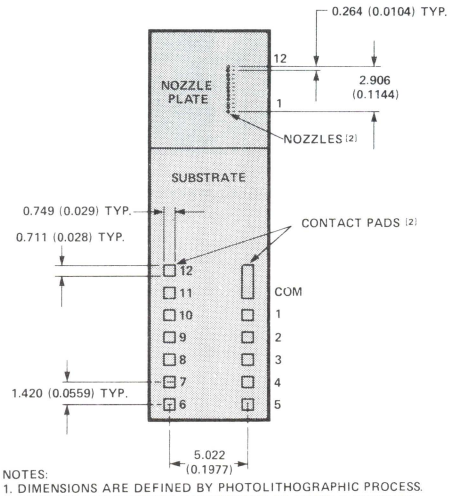
A dot firing frequency of 1250 Hz provides a printing speed of 13 inches/sec at 96 dots/inch resolution. This is equivalent to over 155 characters per second at a density of 12 characters per inch. A 2000 Hz dot frequency is possible under certain low dot density printing conditions, such as low resolution text. The typical ink capacity of 10 million dots will provide approximately 500K characters using a common 96 dots/inch square font. Higher character capacities can be achieved by reducing the font resolution (fewer dots per character).

Unlike multi-use ribbons used in dot matrix printers, the print quality is consistent over the life of the print cartridge. The print cartridge will print on a wide variety of papers and porous surfaces. Optimum print quality is obtained on HP designated papers.

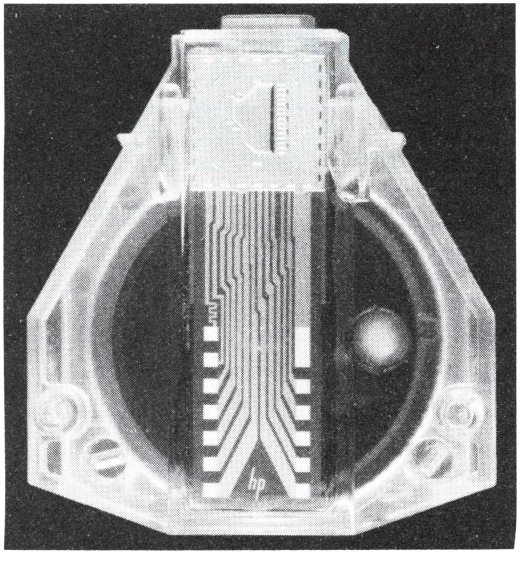
PHYSICAL DIMENSIONS



SUBSTRATE/CONNECTOR DETAIL



NOTES:
1. DIMENSIONS ARE DEFINED BY PHOTOLITHOGRAPHIC PROCESS.
2. CONTACT PAD NUMBERS CORRESPOND TO NOZZLE NUMBERS.
3. CONTACT PADS ARE GOLD PLATED FOR CORROSION PROTECTION; MATING CONTACTS SHOULD AVOID SCRATCHING.



Maximum Ratings

Parameter	Max. Rating	Units	Conditions
Number of dots per print cartridge[1]	10	M Dots	
Nozzle life	2	M Dots	Any single nozzle
Shelf life	18	Mos.	At 25°C in container
Shelf life	6	Mos.	At 25°C outside container
Non-operating temperature	60	°C	48 hours

Note:
1. Actual number of dots is application dependent. Value shown is typical.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Conditions
Nozzle to Media Spacing[1, 2]		0.65 (0.025)	1.15 (0.045)	mm (inches)	
Operating Temperature[3]	T_{OP}	10	40	°C	
Operating Humidity[3]	H_{OP}	5	80	% R.H.	25°C
Operating Altitude	—	0	4500	Meters	25°C

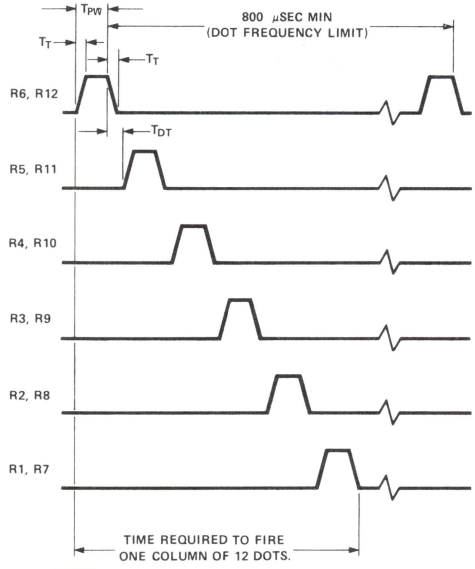
Notes:
1. Clogging may result if media comes in contact with print cartridge.
2. Larger spacing may be used but with degradation in print quality.
3. Prefiring may be required in low humidity and some low temperature conditions.

Electrical Specifications

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Resistance (pad to common)	Rpp	55		70	Ohms	
Dot frequency		0		1250	Hz	All nozzles firing
Dots fired simultaneously				2	Dots	
Operating Energy (pad to common)	E_{OP}		36.5		μJ	T_{PW} = 4.5 μs R_{PC} = 65 Ohms
			40.5		μJ	T_{PW} = 6.0 μs R_{PC} = 65 Ohms
Operating Voltage (pad to common)	V_{OP}	22.0	23.0	24.0	Volts	T_{PW} = 4.5 μs
		20.0	21.0	22.0	Volts	T_{PW} = 6.0 μs
Pulse Width[1]	T_{PW}	4.5	4.5	6.0	μsec	
Dead Time	T_{DT}	0	0.5		μsec	
Transition Time	T_T			500	nsec	10-90%

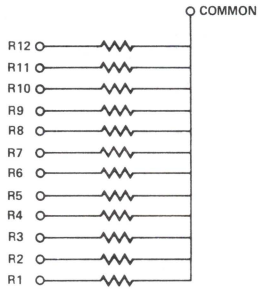
Note:
1. Any pulse width tolerance must be compensated by tightening the voltage variation to maintain an equivalent pulse energy as if there were no pulse width variation.

RESISTOR FIRING TIMING DIAGRAM



NOTES:
OTHER SEQUENCES ARE POSSIBLE.
NO MORE THAN TWO DOTS FIRED SIMULTANEOUSLY.

SCHEMATIC DIAGRAM



Supporting Information

For further information, refer to:
"Thermal Ink-jet Print Cartridge Designer's Guide",
Publication #5954-8400
"Hewlett-Packard Journal", May 1985,
Publication #5953-8535.

These documents are available through your local HP component sales office.

Safety Information

The ink used in the print cartridge includes Diethylene Glycol, which may be harmful if swallowed, but is non-toxic. Test results regarding toxicity and other health considerations are available on request.

This product complies with the Consumer Safety Protection Code of the Federal Regulations as well as the EPA New Chemical Product Regulations.

No special procedures are necessary in disposing of the print cartridge.

Ordering Information

PART NUMBER	DESCRIPTION
92261A	Black Ink Print Cartridge
51605B	Blue Ink Print Cartridge
51605R	Red Ink Print Cartridge
51605G	Green Ink Print Cartridge
51610A	Carriage Assembly with Flex Circuit from the Hewlett-Packard ThinkJet Printer

HEWLETT PACKARD

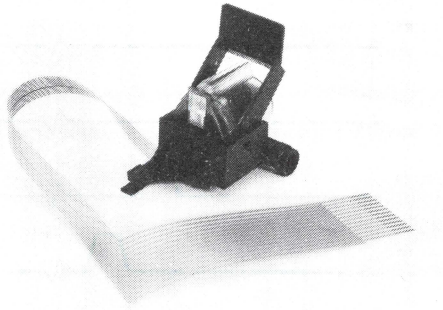
CARRIAGE ASSEMBLY FOR THE THERMAL INK-JET PRINT CARTRIDGE

51610A

For use with HP print cartridges #: 92261A, 51605B, 51605R, 51605G

Features

- PROVIDES MECHANICAL AND ELECTRICAL INTERCONNECT FOR THE THERMAL INK-JET PRINT CARTRIDGE
- EASY PRINT CARTRIDGE REPLACEMENT
- PRECISION MECHANICAL INTERCONNECT
- SIMPLE, RELIABLE, PRESSURE ELECTRICAL CONTACTS
- 8 INCH PRINT ZONE SCANNING WIDTHS
- BUILT-IN POSITION DETECTOR ARM



Note: Print cartridge not included with 51610A

Description

The 51610A carriage assembly is a totally self-contained unit for connecting the HP Thermal Ink-jet print cartridge to a host printing device. It includes all the parts necessary to provide both electrical and mechanical interconnect and comes totally pre-assembled. The 51610A is the same carriage assembly used in the HP ThinkJet printer.

Insertion or removal of the print cartridge from the carriage assembly requires no tools and takes only a few seconds to complete. Insertion is done by simply dropping the cartridge into the carriage assembly and then rotating a cammed head latch upward as shown in Figure 2.

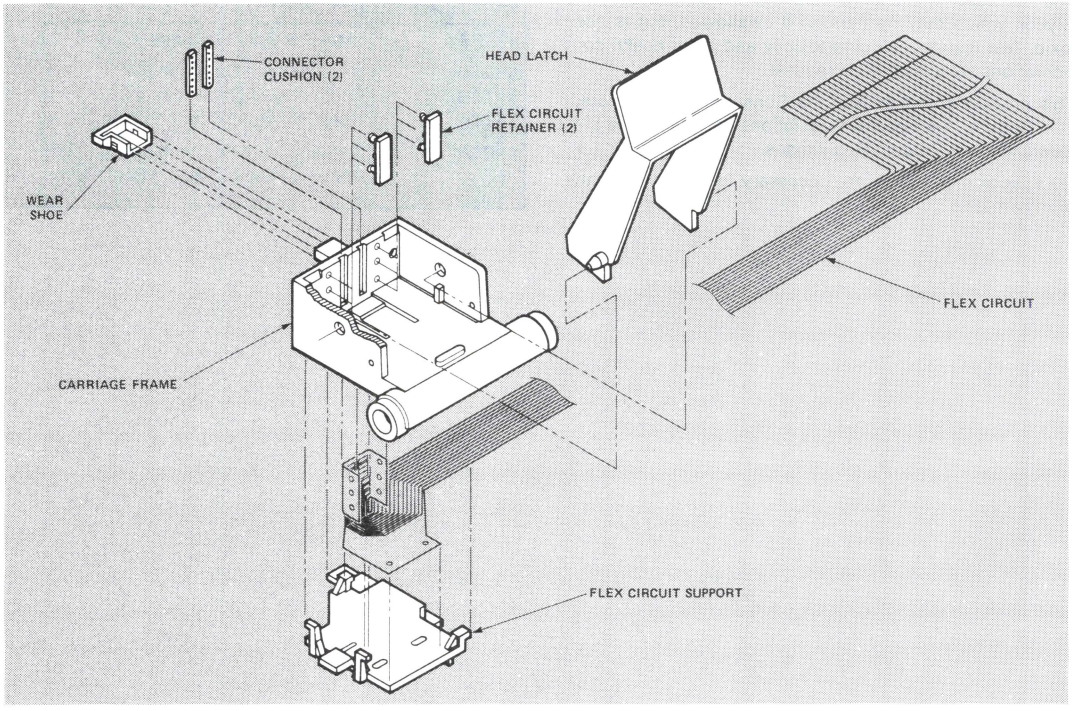
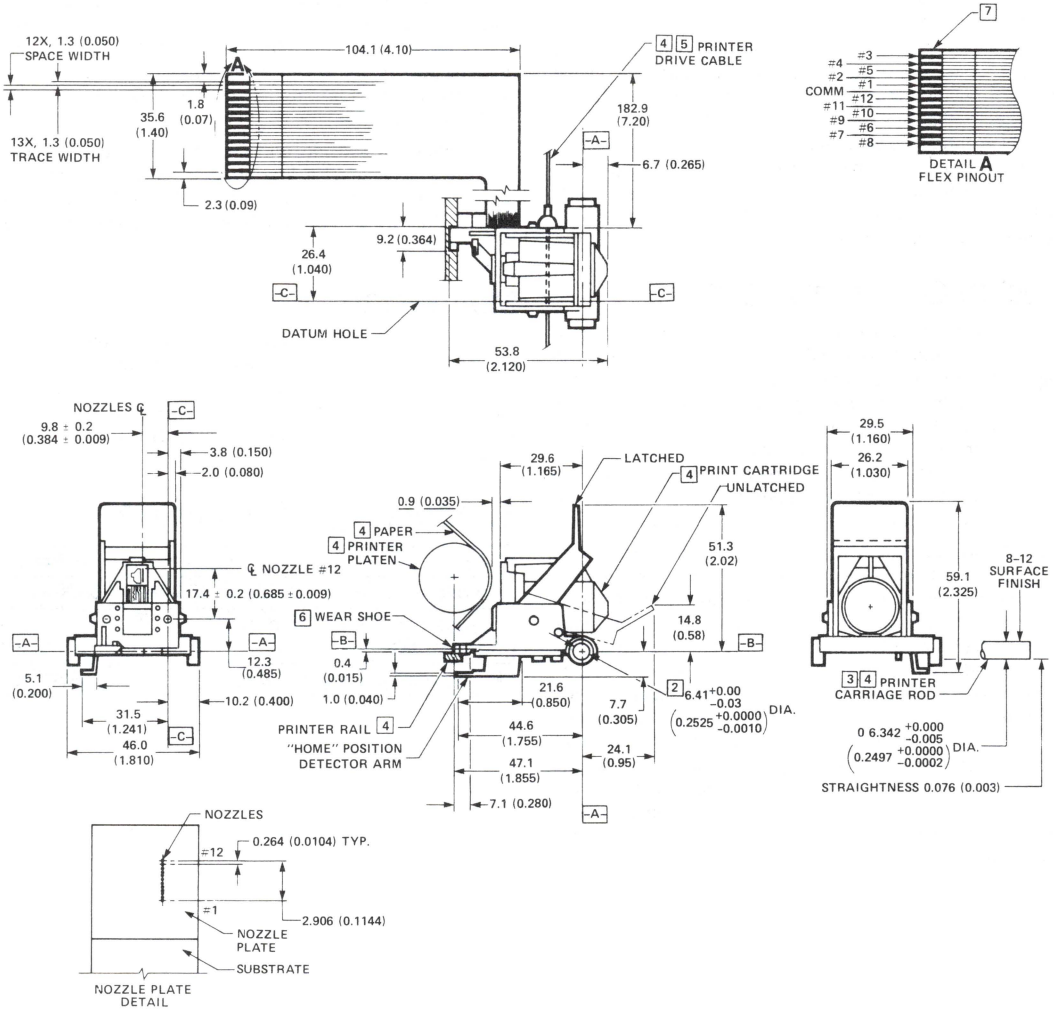


Figure 1. Exploded View



1. DIMENSIONS ARE IN MM (INCHES).
2. MATERIAL IS NYLON 6/6 BLENDED WITH GLASS FIBER (30 %), TFE (13 %) AND SILICONE (2 %).
3. PROVIDES PRIMARY MOUNTING SURFACE. MATERIAL SHOULD BE 303 STAINLESS STEEL WITH CLEAR PASSIVATION FINISH. NO LUBRICATION IS NECESSARY OR RECOMMENDED.
4. NOTED PARTS ARE NOT INCLUDED IN CARRIAGE ASSEMBLY, BUT ARE SHOWN TO ILLUSTRATE APPLICATION.
5. PROVIDES CARRIAGE MOVEMENT ACROSS PRINT ZONE. CABLE SHOULD BE ROUTED TO BIAS THE WEAR SHOE AGAINST THE PRINTER RAIL.
6. PROVIDES ANGULAR REFERENCE POINT. MATERIAL IS ACETAL FILLED WITH 20 % TFE, LNP # FULTON 404 OR EQUIVALENT.
7. CONTACT AREAS ARE PLATED WITH 30 MICROINCHES MINIMUM HARD GOLD (KNOOP 130 MINIMUM OVER 30 $^{+30}_{-15}$ MICROINCHES OF NICKEL).

Figure 2. Outline Drawing With Printer Interface.

A flexible printed circuit provides electrical connection to both the print cartridge and the host printer without the need for additional connectors. This flex circuit also allows the print cartridge to be scanned across print zone widths of up to 8 inches.

A specially designed pressure interconnect system provides reliable electrical contact to the print cartridge over a wide range of environmental conditions while minimizing any damage to the print cartridge contact pads. Electrical contact is enhanced by using a special dimpling technique on the flex circuit. This provides a greater degree of insensitivity to paper dust and ink contamination. It also makes the contact area easy to clean if contaminants become excessive (see Maintenance).

Design Considerations

The carriage assembly is intended to be mounted on a carriage rod and moved with a drive cable as shown in Figure 2. The direction of drop firing is controlled by the angular position of the carriage assembly on the carriage rod. A wear shoe (see Figure 2) provides the means for maintaining this angular reference by riding on a low friction printer rail in the host printer. If ink firing is done in a horizontal orientation, gravitational forces on the carriage assembly can be utilized to maintain this mating.

The 51610A carriage assembly is intended to be used in applications where the paper path is curved, such as with a round printer platen as shown in Figure 2. This allows the paper to be brought closer to the print cartridge nozzles than with a flat paper path. Optimum print quality is obtained by maintaining the recommended nozzle to paper spacing of 0.65 to 1.15 mm. Larger spacings are possible, but with some degradation in print quality (see Thermal Ink-jet Print Cartridge Designer's Guide). To maintain the recommended spacing, it is important that the printer designer maintains good dimensional control from the printer/carriage mating surfaces to the paper surface, and understands which tolerances are important in a given application.

Electrical connection to the host printer may be made with a standard printed circuit board connector, Amp #1-520315-3.

A home position detector arm on the carriage assembly may be used to detect when the carriage assembly passes one or more detector locations on the printer. This may be done by passing the detector arm through an interruptable type optical sensor. Suggested parts: Optek #K-8150, Kodenshi #SG-HP01.

For continuous sensing and control of carriage motion, HP offers an extensive line of rotary and linear motion sensing and control components. Contact your local Hewlett-Packard Component Sales Representative for more information.

Maintenance

No routine cleaning or lubrication is required for the carriage assembly. If excessive contamination of the electrical contacts causes loss of print, gently wipe the contacts with a swab dampened with Iso Propyl Alcohol as shown in the Print Cartridge Designer's Guide. Avoid harsh scrubbing.

Supporting Information

Title	HP Pub #
Thermal Ink-jet Print Cartridge Data Sheet	5954-8399
Thermal Ink-jet Print Cartridge Designer's Guide	5954-8535
Hewlett-Packard Journal, May 1985	5953-8535

Bar Code Components

- SmartWand
- Digital Wands
- Decoder ICs
- Optical Sensor
- Readers

Bar Code Products

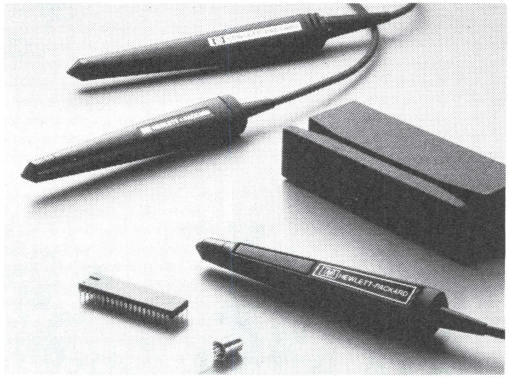
The HP SmartWand family (HBCR-8XXX) is the latest addition to the wide range of bar code products offered by Hewlett-Packard. The HP SmartWand is an intelligent peripheral designed to easily add bar code scanning capability to any host system which can support a 5 V serial asynchronous interface. This device is designed specifically for the OEM who would rather not expend valuable resources developing software and integrating system hardware to support bar codes. A powerful microcomputer, bar code decoding software, optical and escape sequence programmability, non-volatile configuration memory, and a high performance contact scanner, are all combined into a standard size industrial wand package.

The HP digital wand selection now includes four product families to meet the performance and price requirements of every customer application. The state-of-the-art Low Current Digital Bar Code Wands are available in both a metal case for indoor/outdoor rugged industrial applications (HBCS-6XXX) and a polycarbonate case for commercial/office applications (HBCS-5XXX). Through an advanced optical sensor and signal processing circuitry, these wands are able to provide superior performance while drawing 3.5 mA at 5 V. In addition to the very low power requirements, the advanced design allows performance improvements which include high ambient light rejection, including direct sunlight; a wider range of resolution choices; and a sensor which reads thermally printed bar codes. For customers who do not require the state of the art performance of the Low Current Digital Bar Code Wands the Sapphire Tip Digital Bar Code Wands (HBCS-2XXX) offer an attractive alternative, particularly for the commercial/office environment where control over label quality is high. For those customers beginning to use barcode scanners or addressing consumer applications, Digital Bar Code Wands (HEDS-3XXX) provide a very cost effective solution.

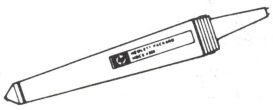
The decoder IC family now includes three product lines. The most recent, HBCR-2010, is a CMOS version of the Multi-Purpose HBCR-2000. This product is especially well suited for low power/portable applications and like the HBCR-2000, can decode the output from virtually any hand-held scanning device, including hand-held lasers and other solid state non-contact scanners. The general purpose digital wand decode IC, HBCR-1800, offers both full duplex serial or parallel output and provides a powerful, cost competitive decode solution. All the decode ICs are in 40 pin DIP packages.

Hewlett-Packard's Industrial Digital Slot Reader, HBCS-7XXX, is a rugged scanner designed specifically for reading bar codes printed on I.D. cards, badges, heavy paper stock, or traveling forms. It features a large slot width for handling even multiple laminated cards, a wide scan speed range, and digital output that is compatible with wand decoding software.

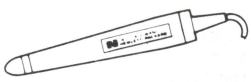
Completing the product mix is the High Resolution Optical Reflective Sensor, HBCS-1100. The HBCS-1100 is a unique 0.19 mm resolution sensor packaged in a standard TO-5 header. This product is a cost effective, dependable solution.



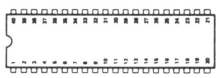
Bar Code Wands

Package Outline Drawing	Part No.	Description	Features	Page No.
	HBCR-8100	HP SmartWand Programmable Contact Bar Code Reader Low Resolution (0.33 mm)	• Automatic Recognition and Decode of Standard Codes • 5 V Serial Asynchronous Output • All Code Reading Parameters Optical/Escape Sequence and Configurable • Configuration Stored in Non-Volitile Memory • Standard Size Epoxy Coated Metal Case • 655 Nanometer Sensor on Low and Medium Resolution • Direct Sunlight Operation	3-6
	HBCR-8300	HP SmartWand Programmable Contact Bar Code Reader Medium Resolution (0.19 mm)		
	HBCR-8500	HP SmartWand Programmable Contact Bar Code Reader High Resolution (0.13 mm)		
	HBCS-5000	Low Current Digital Bar Code Wand (with Switch) Resolution 0.33 mm	• Low Continuous Current Draw (Less Than 5 mA) • High Ambient Light Rejection • 0 to 45° Scan Angle • Push to Read Switch for Ultra Low Power Consumption • Rugged Polycarbonate Case • Sealed Sapphire Tip • Full Line of Options Available	3-13
	HBCS-5100	Low Current Digital Bar Code Wand (without Switch) Resolution 0.33 mm		
	HBCS-5200	Low Current Digital Bar Code Wand (with Switch) Resolution 0.19 mm		
	HBCS-5300	Low Current Digital Bar Code Wand (without Switch) Resolution 0.19 mm		
	HBCS-5400	Low Current Digital Bar Code Wand (with Switch) Resolution 0.13 mm		
	HBCS-5500	Low Current Digital Bar Code Wand (without Switch) Resolution 0.13 mm		
	HBCS-6100	Low Current Digital Bar Code Wand Resolution 0.33 mm	• Low Continuous Current Draw (Less Than 5 mA) • High Ambient Light Rejection • 0 to 45° Scan Angle • Sealed Sapphire Tip • Metal Case • Full Line of Options Available	
	HBCS-6300	Low Current Digital Bar Code Wand Resolution 0.19 mm		
	HBCS-6500	Low Current Digital Bar Code Wand Resolution 0.13 mm		

Bar Code Wands (Cont.)

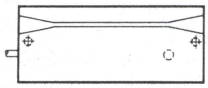
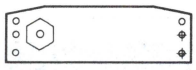
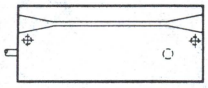
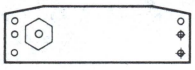
Package Outline Drawing	Part No.	Description	Features	Page No.
	HBCS-2200	Sapphire Tip Digital Bar Code Wand (with Switch) Resolution 0.19 mm	• Digital Output • 0-45° Scan Angle • Replaceable Sapphire Tip • Internal Shielding • Push-to-Read Switch Available for Low Power Applications • Rugged Polycarbonate Case • Full Line of Options Available	3-19
	HBCS-2300	Sapphire Tip Digital Bar Code Wand (without Switch) Resolution 0.19 mm		
	HBCS-2400	Sapphire Tip Digital Bar Code Wand (with Switch) Resolution 0.19 mm		
	HBCS-2500	Sapphire Tip Digital Bar Code Wand (without Switch) Resolution 0.13 mm		
	HEDS-3000	Digital Bar Code Wand (with Switch) Resolution 0.3 mm	• Digital Output • 0-30° Scan Angle • Replaceable Tip • Internal Shielding Available for Improved Electrical Noise Rejection • Push-to-Read Switch Available for Low Power Applications • Full Line of Options	3-25
	HEDS-3050	Digital Bar Code Wand (Shielded) Resolution 0.3 mm		

Component Level Bar Code Readers

Package Outline Drawing	Part No.	Description	Features	Page No.
	HBCR-1800	Bar Code Decoder IC	• Industry Standard Bar Codes • Automatic Code Recognition • Full Duplex Serial or Parallel ASCII Output • Single 5 Volt Supply	3-31
	HBCR-2000	Multi-Purpose Decoder IC	• Accepts Inputs from All Hand-Held Scanners, Including Lasers • Largest Selection of Codes Available • Automatic Code Recognition • Serial ASCII Output • Standard 40 Pin Package	3-37
	HBCR-2010	CMOS Multi-Purpose Decoder IC	• CMOS Low Power Design • Accepts Inputs from All Hand-Held Scanners, Including Lasers • Largest Selection of Codes Available • Automatic Code Recognition • Serial ASCII Output • Standard 40 Pin Package	3-43

Package outline drawings not drawn to scale.

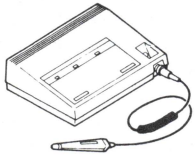
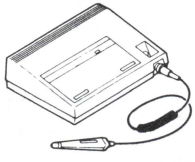
Component Level Bar Code Readers (Cont.)

Package Outline Drawing	Part No.	Description	Features	Page No.
	HBCS-7000	Industrial Digital Slot Reader, Visible Red, Resolution 0.19 mm	• 125 Mil Slot Width • Epoxy Finshed Metal Housing • Wide Scan Speed Range • Tamper Proof Design • Digital Output	3-44
	HBCS-7001	Optics/Electronics Module, Visible Red, Resolution 0.19 mm		
	HBCS-7100	Industrial Digital Slot Reader, Infra-Red Resolution 0.19 mm		
	HBCS-7101	Optics/Electronics Module, Infra-Red, Resolution 0.19 mm		

Optical Reflective Sensors

Package Outline Drawing	Part No.	Description	Features	Page No.
	HBCS-1100	High Resolution Optical Reflective Sensor	• 0.19 mm spot size • Fully Specified and Guaranteed for Assured Perfomance • Visible Light Source can Detect Most Colors • Photo IC Detector Optimizes Speed and Response • Standard To-5 Header	3-50

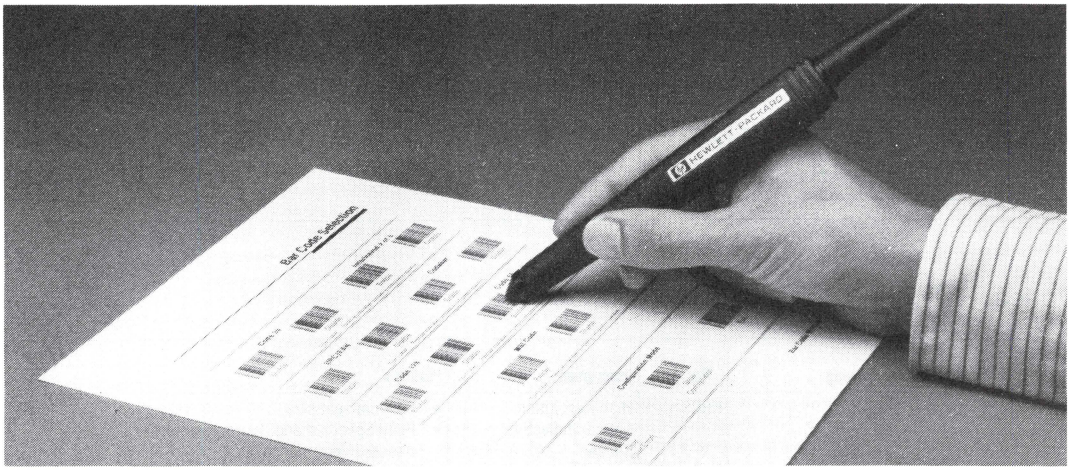
Bar Coder Readers

Package Outline Drawing	Part No.	Description	Features	Page No.
	16800A	Programmable Bar Code Reader	• Flexible Configuration • All Standard Industrial and Commercial Bar Codes Supported • Computer Control and Simple Operator Feedback (16800A only) • Internal Power Supply • Meet UL, CSA, FCC Class B, VDE Level B • Low Current Digital Bar Code Wand Included	3-56
	16801A	Non-Programmable Bar Code Reader		

HEWLETT PACKARD

HP SmartWand Programmable Contact Bar Code Reader

HBCR-8300 General Purpose
HBCR-8500 High Resolution
HBCR-8100 Low Resolution



Description

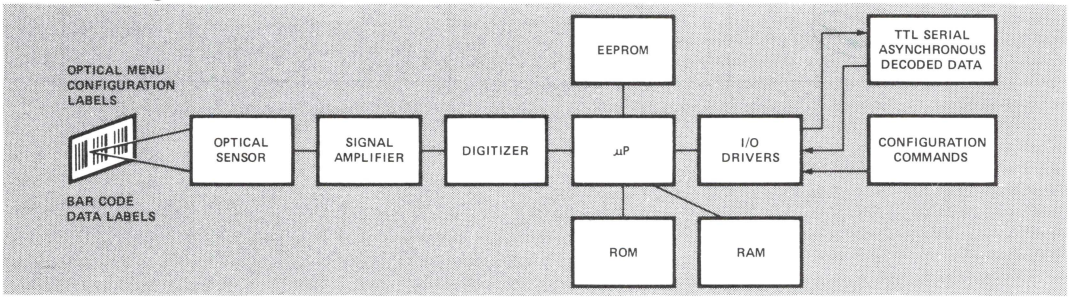
The HP SmartWand is an intelligent peripheral designed to easily add bar code scanning capability to any host system which can support a 5 V serial asynchronous interface. A powerful microcomputer, bar code decoding software, optical and escape sequence programmability, non-volatile configuration memory, and a high performance contact scanner, are all combined into a standard size industrial wand package. This integrated system transmits decoded bar code data in a serial ASCII format, effectively freeing the host system processor from the decoding task. The optics and low power electronics allow operation in a wide range of environments including direct sunlight, intense aritificial light, and in electromagnetic fields caused by motors or radio frequency transmitters.

The epoxy coated, textured metal case has O-ring seals at each end, a labyrinth strain relief for the cord, and a replaceable sealed sapphire tip. These design features prevent dust, dirt, and liquid contaminants from degrading or destroying components inside the wand.

The HP SmartWand automatically recognizes and decodes standard bar code symbologies. Code type identification, label length checking, and check character verification options when enabled ensure a high level of data integrity. A power-on memory self test option ensures the decoder is operating properly. Various code selections, interface protocols, and other control options, can be selected and automatically stored in non-volatile memory by either manually scanning a special bar code menu or transmitting escape sequences from the host system.

In addition, the HP SmartWand has the ability to convert any of the standard bar code symbologies to Code 39 and emulate the undecoded output of a digital wand. This allows an existing decode system, which can decode Code 39, to include symbologies not previously available.

Block Diagram



Contact Scanner Performance

SUMMARY

The HP SmartWand is a high performance contact bar code reader designed to scan and decode bar code labels located on uniform surfaces. The optics in the wand are designed to operate with the tip touching the bar code labels while scanning. The scanner is capable of reading through plastic laminates up to 0.25 mm (0.010") thick. The synthetic sapphire ball which contacts the labels is self cleaning and nearly impervious to wear. The low weight and compact shape allows ease of use and helps to reduce worker fatigue. The rugged industrial design allows use in both indoor and outdoor environments.

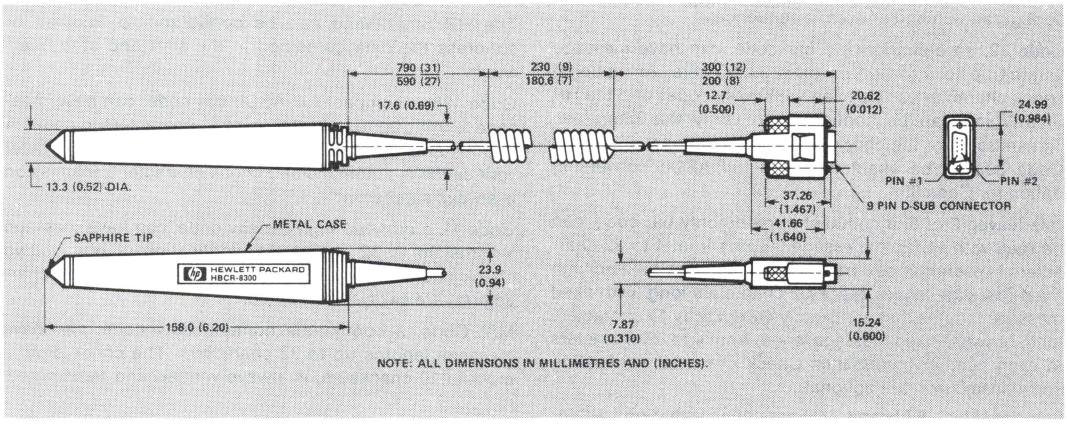
TYPICAL WAND CHARACTERISTICS

Parameter	HBCR-8300 General Purpose	HBCR-8500 High Resolution	HBCR-8100 Low Resolution
Nominal Narrow Element Width	0.19 mm (0.0075 in.)	0.13 mm (0.005 in.)	0.33 mm (0.013 in.)
Wavelength	655 nm (visible red)	820 nm (infrared)	655 nm (visible red)
Scan Speed	3-50 in./sec.	3-50 in./sec.	3-50 in./sec.
Tilt Angle	0° - 40°	0° - 40°	0° - 40°
Minimum Bar/Space Contrast at Specified Wavelength	45%	45%	45%

ENVIRONMENTAL PERFORMANCE

Parameter	Conditions
Operating Temperature	-20° to +70° C (-4° to 158° F)
Storage Temperature	-40° to +70° C (-40° to +158° F)
Humidity	5% to 95% (non-condensing)
Operating Altitude	Sea Level to 4,600 metres (15,000 feet)
Storage Altitude	Sea Level to 15,300 metres (50,000 feet)
Vibration	Random: 5-500 Hz, 3.41g rms, 10 minutes per axis Swept Sine: 55-500 Hz, @ 3 g, 1 minute/octave, 10 minutes each resonance
Shock	500 g's at 1 millisecond, 18 shocks (3 each, 6 surfaces)
Ambient Light	0 to 100kLux (Direct sunlight)
Rain	MIL-STD-810, Method 506, Procedure II, Drip
Dust	MIL-STD-810, Method 510, Blowing Dust

Mechanical Specifications



Programmable Configuration

The HP SmartWand can be configured by scanning a series of special menu labels or by transmitting escape sequences from the host system to the wand. This allows decoding options and interface protocols to be tailored to a specific application. The configuration is stored in non-volatile memory and cannot be changed by removing power from the wand or by scanning standard bar code labels. The configuration information can be transmitted to the host system by scanning a bar code label in the configuration menu or by sending the appropriate escape sequence from the host system. The wand can be reconfigured at any time to accommodate changing application requirements. Configuration labels and the escape sequences with detailed instructions on how to use each of them are printed in the HP SmartWand Users Manual (Part # HBCR-8997). Configuration labels (Part # HBCR-8998) can also be purchased separately as an accessory.

An example configuration display screen with the default settings is shown.

CONFIGURATION DISPLAY SCREEN

CONFIGURATION DISPLAY SCREEN			version 12.X				(c) Hewlett Packard 1986
CODE	READ	CHECK CHAR		LENGTH		CODE ID	OTHER CONFIG. SETTINGS
		verif	xmit	min	max	xmit:(off)	
Code 39	(yes)	(no)	(yes)	(1)	(32)	(a)	
Int. 2/5	(yes)	(no)	(yes)	(4)	(32)	(b)	(variable length)
UPC/EAN	(yes)	yes	yes	fixed		(c)	
Codabar	(yes)	no	no	(1)	(32)	(d)	(start/stop transmitted)
Code 128	(yes)	yes	no	(1)	(32)	(e)	
Code 11	(yes)	(1)	yes	(1)	(32)	(f)	
MSI Code	(yes)	yes	yes	(1)	(32)	(g)	

MESSAGE COMPONENTS (control character = ∧ + letter)

header:( )	no-read: ( )
trailer: (∧M ∧J)	message ready:(∧F)
reader address:( )	message not ready:(∧U)

SERIAL PORT	PACING	MISCELLANEOUS
baud rate:(9600)	XON/OFF protocol:(off)	no-read recognition:(off)
parity: (0's)	Single Read Mode:(off)	scanner:(enabled)
stop bits:(1)		
(20ms)delay:(off)		

Note: This is a partial listing of configurable parameters. Please refer to the HP SmartWand Users Manual (Part # HBCR-8997) for a complete listing.

Bar Code Decoding Performance

BAR CODE SYMBOLOGIES SUPPORTED

The HP SmartWand automatically recognizes and decodes Code 39 (3 of 9 Code), Interleaved 2 of 5, Universal Product Code (UPC), European Article Numbering Code (EAN), Japanese Article Numbering Code (JAN), Codabar (NW7 Code), Code 128, MSI Code, and Code 11. Minimum and maximum length values can be configured for each code (except UPC/EAN/JAN) and all codes can be scanned bi-directionally. All code types and their decoding format options can be enabled or disabled using either the optical configuration menu or escape sequences.

Code 39, an alphanumeric bar code, can have message lengths up to a maximum of 32 characters. An optional check character can be used with these codes and the HP SmartWand can be configured to verify this character. Transmission of the check character is optional. Extended Code 39 can be enabled as the full ASCII conversion option for Code 39.

Interleaved 2 of 5, a compact numeric only bar code, can be read with variable message lengths from 4 to 32 characters in even number increments. It can also be read with fixed message length exactly 2 characters long, with fixed message lengths that are exactly 6 or exactly 14 characters long, or with a fixed message length from 4 to 32 characters in even number increments. Check character verification and transmission are optional.

Standard UPC, EAN and JAN bar codes including UPC-A, UPC-E, EAN-8, EAN-13, JAN-8 and JAN-13 are fixed length numeric only bar codes that have automatic check character verification and transmission. Decoding can be restricted to UPC-A and UPC-E. UPC-E labels can be expanded into the UPC-A format upon transmission. Supplemental encodations can be enabled in 2 digit, 5 digit, or both 2 and 5 digit lengths. Labels with supplemental encodations, or "add-on's" must be scanned from left to right in one stroke so that the supplementals are scanned after the main label. When automatic recognition of supplemental encodations is enabled, labels with or without add-on's are decoded.

Codabar, a numeric bar code with special characters, can have a message lengths up to a maximum of 32 characters. The HP SmartWand can be configured to transmit or suppress the data contained in the start and stop characters.

Code 128, a compact full ASCII bar code, can have message lengths up to a maximum of 31 characters in codes A and B, and 62 characters in code C. Check character verification is automatic and check character transmission is always suppressed.

Code 11, a numeric high density code, can have message lengths up to 32 characters. Verification of one or two check characters must be enabled, and the check character(s) are always transmitted.

MSI Code, a continuous numeric only code, can have message lengths up to 32 characters. The check digit, a modulo 10 checksum, is always verified and transmitted.

DECODING PARAMETERS

Parentheses indicate the parameter is optically configurable. Brackets indicate the parameter is escape sequence configurable. Default settings are shown.

Other default decoding parameters:
Extended Code 39 (full ASCII conversion) is disabled.
Interleaved 2 of 5 message length is variable.
UPC/EAN/JAN supplemental digits are disabled.
Codabar stop/start characters are transmitted.

Code	Code Status	Check Character		Message Length		Code I.D. Character
		Verification	Transmit	Minimum	Maximum	Transmit [(disabled)]
Code 39	[(enabled)]	[(disabled)]	[(yes)]	(1)	(32)	[(a)]
Interleaved 2 of 5	[(enabled)]	[(disabled)]	[(yes)]	[(4)]	[(32)]	[(b)]
UPC/EAN/JAN	[(enabled)]	yes	yes	fixed		[(c)]
Codabar	[(enabled)]	no	no	(1)	(32)	[(d)]
Code 128	[(enabled)]	yes	no	(1)	(32)	[(e)]
Code 11	[(enabled)]	[(1)]	yes	(1)	(32)	[(f)]
MSI Code	[(enabled)]	yes	yes	(1)	(32)	[(g)]

MESSAGE COMPONENTS

There are three optical or escape sequence configurable message components that can be defined by the user and added to the decoded data transmitted by the HP Smart-Wand. The message components are: header, trailer, and code identification character. A no-read message option is also available.

The header, which precedes the decoded data, and the trailer, which follows the decoded data, can contain up to 10 ASCII characters. The code identification character is a single ASCII character which immediately precedes the decoded data and is used to identify the bar code symbology that was decoded. The no-read message can be up to 10 ASCII characters and can be transmitted in place of decoded data if a bar code label is scanned and a decode does not occur.

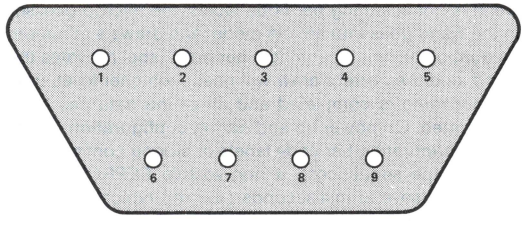
The default settings for the message components are shown.

Message Parameter	Configurable Options	Default Setting
Header:	0 to 10 ASCII characters	0 Characters (empty buffer)
Trailer:	0 to 10 ASCII characters	C_R L_F
No Read Message:	0 to 10 ASCII characters	0 Characters (empty buffer)
Code Identification Character:	1 ASCII character	See "Decoding Parameters" table

Electrical Interface

PIN DIAGRAM

Pin #	Wire Color	Function
1	—	N/C
2	White	TxD Transmitted Data (from the wand)
3	Green	RxD Received Data (to the wand)
4	—	N/C
5	—	N/C
6	—	N/C
7	Black	Ground
8	—	N/C
9	Red	V_{CC}
Shell	—	Shield

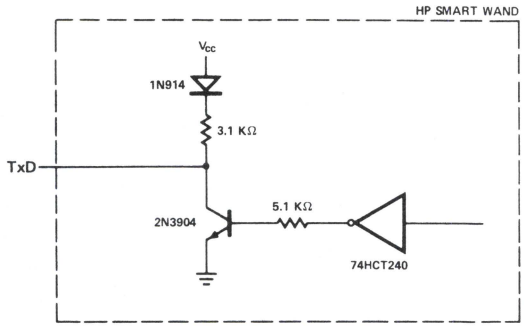


MALE 9 PIN SUBMINIATURE D CONNECTOR

Pin Description

PIN 2

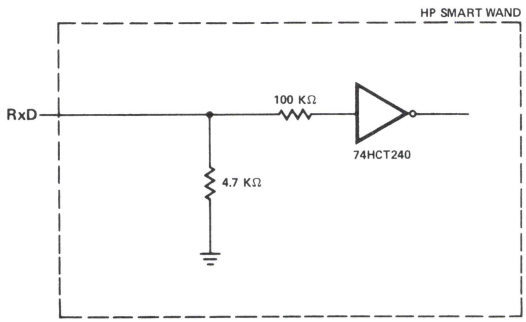
TxD — This is the transmitted serial data line from the HP SmartWand. It obeys RS232 data formats, but uses zero to five volt logic level swings. It can be described as TTL level RS232. This will drive TTL, LSTTL, and CMOS inputs. The output circuit is shown:



TxD Output Specifications (V_{CC} = 5 Volts DC @ T_A =25° C)		
V_{OH}	2.00 VDC @ 740 μA 3.00 VDC @ 410 μA 4.00 VDC @ 95 μA	[$V_{OH} = V_{CC}$-0.7-(3100 *I_{OH})]
V_{OL}	0.30 VDC @ 20 mA	
I_{OL}	20 mA maximum	
V_{MAX}	30 VDC	(maximum voltage for external pull up resistor)

PIN 3

RxD — This is the received serial data line to the HP SmartWand. It expects RS232 serial data formats, and will accept either RS232 signal levels (-3 to -15 volts low and +3 to +15 volts high), or TTL levels (0.8 volts low and 2.0 volts high). The two resistors provide current and voltage protection to the CMOS gate. This allows the use of RS232 level voltages. -15.0 to +0.8 volts are valid logic low levels. +2.0 to +15.0 are valid logic high levels. The input circuit is shown:



RxD Input Specifications (V_{CC} = 5 Volts DC @ T_A =25° C)	
V_{IH}	2.00 VDC @ 500 μA
V_{IL}	0.80 VDC @ 1 μA

PIN 9

V_{CC} — This is power to the wand. The allowable voltage range is 4.50 to 6.00 volts DC with a maximum of 100 millivolts of peak to peak ripple (20 Hz - 50 kHz). The current draw of the HP SmartWand is variable. When the wand is not scanning bar code labels, the microprocessor in the wand goes into an idle mode, and draws a minimum amount of current. Scanning a bar code label activates the wand, and the current draw will rise to a higher level, until the decoding is completed and all of the data has been transmitted. On power up and during configuration (scanning configuration bar code labels or storing configuration with escape sequences), a non-volatile EEPROM is accessed for several milliseconds (100 mS typical), and the wand requires a higher current level.

V_{CC} Values		
	Min	Max
Operating voltage, V_{CC}	4.5 VDC	6.0 VDC
Absolute rating, V_{CC}	-0.3 VDC	6.0 VDC

Typical I_{CC} Values			
V_{CC}	4.5 volts	5.0 volts	6.0 volts
I_{CC} Idle	9 mA	10 mA	12 mA
I_{CC} Scanning	14 mA	16 mA	20 mA
I_{CC} Configuring	23 mA	25 mA	29 mA

PIN 7

Ground — The HP Smart Wand needs to be well grounded for proper protection.

SHELL

Shield - Shield is connected to the metal housing, the wire braid, and the metal HP SmartWand Case. Shield is also connected to ground inside the HP SmartWand.

DATA COMMUNICATIONS

Data Communications Parameters	Configurable Options	Default Setting
Data Rate:	150, 300, 600, 1200, 2400, 4800, 9600, 19.2 K Baud	9600 Baud
Parity:	0's, 1's, odd, even	0's Parity
Stop Bits:	1 or 2	1 stop bit
Intercharacter Delay:	1 to 250 milliseconds enabled or disabled	20 milliseconds disabled

RS232 COMPATIBILITY

Input to the HP SmartWand is fully RS232 compatible. Output from the HP SmartWand is not at RS232 levels, and does not meet RS232 specifications for voltage swings. A majority of RS232 interfaces on computers and other equipment will allow use of TTL level serial data. The use of a receiver IC such as the TI75189 or Motorola MC1489, is possible if the response control lines are not connected (the pins left floating). Please refer to the HP SmartWand Users Manual (Part #HBCR-8997) for a more detailed discussion on interfacing the HP SmartWand to other systems.

Regulatory Information

The digital circuitry used to obtain the high performance features of the HP SmartWand includes oscillators which generate radio frequency energy. If not installed and used properly, the wands may cause interference to radio and television reception. The wands have been type tested with the standard connectors and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate the wand with respect to the receiver
- Move the wand away from the receiver

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20422, Stock No. 004-00345-4.

If the HP SmartWand is sold without a connector it is defined as a subassembly and the FCC Identification numbers no longer apply. In those situations, the user has the responsibility to assure FCC compliance of his entire system, both HP SmartWand and host system. Hewlett-Packard assumes no responsibility or liability for users of HP SmartWands without connectors that fail to comply with FCC regulations.

Model	FCC Identification
HBCR-8500	FCC ID: CUP6Z939965D HEWLETT-PACKARD
HBCR-8300	FCC ID: CUP6Z939963D HEWLETT-PACKARD
HBCR-8100	FCC ID: CUP6Z939961D HEWLETT-PACKARD

Warranty and Service

HP SmartWand is warranted for a period of one year after purchase covering defects in material and workmanship. Hewlett-Packard will repair or, at its option, replace products that prove to be defective in material or workmanship under proper use during the warranty period.

NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. HEWLETT-PACKARD IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

For additional warranty or service information please contact your local Hewlett-Packard sales representative or authorized distributor.

HP SmartWand Selection Guide

Product	Bar Code Label Description	Typical Label to be Scanned by this model
HBCR-8300 General Purpose	• Nominal narrow element width of 0.19 mm (0.0075 in.) or greater • Reads uniform dot matrix and standard thermal printing as well as high quality pre-printed labels • DOES NOT read infrared (black on black) security labels	High Density 7.5 mil Code 39 Label
HBCR-8100 Low Resolution	• Nominal narrow element width of 0.33 mm (0.013 in.) or greater • Reads poorer quality dot matrix and standard thermal labels with non-uniform bar edges, minor spots and voids, faded print • DOES NOT read infrared security labels	Low Density 13 mil Code 39 Dot Matrix Label
HBCR-8500 High Resolution	• Nominal narrow element width of 0.13 mm (0.005 in.) or greater • Reads very high density high quality labels printed with carbon based ink • Reads infrared security labels • DOES NOT read standard white thermal printed paper; if thermal printed labels are to be used, they MUST BE PRINTED on a special infrared type BUFF paper. • DOES NOT work well with poor quality labels.	Very High Density 5 mil Code 39 Label

Ordering Information

Product Number	Description
HBCR-8300	General Purpose HP SmartWand (without manual)
HBCR-8300 Opt. B01	General Purpose HP SmartWand (with manual)
HBCR-8100	Low Resolution HP SmartWand (without manual)
HBCR-8100 Opt. B01	Low Resolution HP SmartWand (with manual)
HBCR-8500	High Resolution HP SmartWand (without manual)
HBCR-8500 Opt. B01	High Resolution HP SmartWand (with manual)

Literature Number	Description
HBCR-8997	HP SmartWand Users Manual for HBCR-8XXX Series

Accessory Number	Description
HBCS-4999	Replacement tip for HBCR-8XXX Series
HBCR-8998	HP SmartWand Configuration Menus for HBCR-8xxx series (set of three)

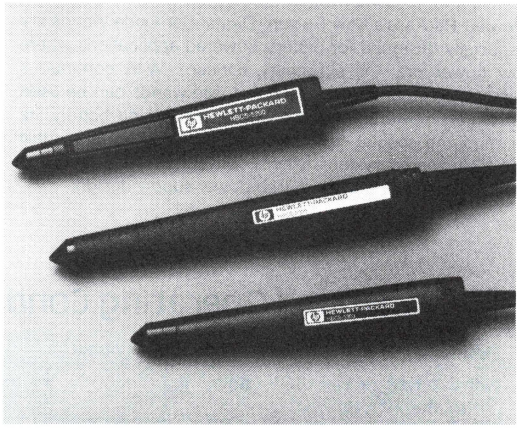
HEWLETT PACKARD

LOW CURRENT DIGITAL BAR CODE WANDS

METAL, LOW RESOLUTION	HBCS-6100
METAL, GENERAL PURPOSE RESOLUTION	HBCS-6300
METAL, HIGH RESOLUTION	HBCS-6500
POLYCARBONATE, LOW RESOLUTION	HBCS-5000/5100
POLYCARBONATE, GENERAL PURPOSE RESOLUTION	HBCS-5200/5300
POLYCARBONATE, HIGH RESOLUTION	HBCS-5400/5500

Features

- **ULTRA LOW CONTINUOUS CURRENT DRAIN**
  - **Less Than 5 mA**
- **HIGH AMBIENT LIGHT REJECTION**
  - **Operates in Direct Sunlight**
- **AVAILABLE IN THREE RESOLUTIONS TO MEET A VARIETY OF SCANNING NEEDS**
- **VISIBLE RED (655 nm) AND INFRARED (820 nm) VERSIONS FOR READING A WIDE RANGE OF PRINTING TYPES AND COLORS**
- **SCAN ANGLE 0 to 45 DEGREES**
- **AVAILABLE IN EITHER HIGH IMPACT POLYCARBONATE OR INDUSTRIAL METAL HOUSINGS**
- **OPERATING TEMPERATURE −20°C to +65°C**
- **SEALED REPLACEABLE SAPPHIRE TIP**
  - **Provides Protection from Contamination Due to Dirt and Debris**
- **DIGITAL OUTPUT**
  - **Open Collector Output Compatible with TTL and CMOS Logic**
- **SINGLE 5 VOLT SUPPLY**



Description

Hewlett-Packard's Low Current Digital Bar Code Wands are hand-held scanners optimized to provide excellent reading of all common bar code formats. The wands contain an optical sensor with a 655 nm visible red or an 820 nm infrared LED; a photodetector IC; and precision aspheric optics. The internal signal conditioning circuitry converts the optical information into a logic level pulse width representation of the bars and spaces.

Available in a choice of three resolutions, these wands have been designed to cover a wide range of bar code printing. The general purpose resolution wands, with their 0.19 mm (0.0075 in.) spot size, are excellent choices for reading a wide range of bar code symbols. For reading very high density symbols, the high resolution wands with a 0.13 mm (0.005 in.) spot size, are the appropriate choice. For lower resolution or poorly printed dot matrix symbols, the low resolution wands have a spot size of 0.38 mm (0.013 in.) to help reject extraneous spots and voids.

All of the wands have a special circuit design that provides for extremely low current drain (less than 5 mA) with continuous operation. This makes them ideal for use on battery powered systems where low power drain will extend battery life. These wands also have excellent ambient light rejection, allowing full operation in direct sunlight.

All of HP's Low Current Digital Bar Code Wands are FCC and VDE approved. They feature a shield for maximizing immunity to electrostatic discharge (ESD), electromagnetic interference (EMI) and ground loops. The shield is also designed to eliminate noise from capacitively coupled inputs.

The standard wand configuration includes a strain relieved coiled cord, which has a comfortable extended length of 190 cm (75 in.). Maximum length is 250 cm (100 in.). The standard connector on the polycarbonate wands is a 5 pin, 240 degree DIN connector. On the metal wands the standard connector is a 5 pin, 240 degree DIN connector with metal locking ring.

Applications

The digital bar code wand is a highly effective alternative to keyboard data entry. Bar code scanning is faster and more accurate than key entry and provides far greater throughput. In addition, bar code scanning typically has a higher first read rate and greater data accuracy than optical character recognition. When compared to magnetic stripe encoding, bar code offers significant advantages in flexibility of media, symbol placement, and immunity to electromagnetic fields.

Hewlett-Packard's Low Current Digital Bar Code Wands are especially designed for battery powered applications where low power drain is a primary concern. With continuous current draws of less than 5 mA, these wands can be used on battery powered systems without sacrificing battery life or requiring special "strobing" circuits. They are also ideal for AC powered systems where conventional wand current drains may require an increased power supply design.

In addition to their low current drain, these wands are also designed to work in high ambient light, such as outdoors or near large windows. This feature is extremely useful in applications such as inventory control on receiving docks, automobile tracking outdoors and check-out stands outdoors or near large store front windows.

Because the low resolution and the general purpose resolution wands use an emitter wavelength of 655 nm, they are extremely versatile in the range of printing type and colors that they will read, including thermal printing and dot matrix printing.

Available in either a light weight polycarbonate case or a rugged metal case, these wands are excellent choices for both light industrial and commercial applications, or heavy industrial and LOGMARS applications.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Notes
Nominal Narrow Element Width					
HBCS-5000/5100/6100		0.33 (0.013)		mm (in.)	
HBCS-5200/5300/6300		0.19 (0.0075)		mm (in.)	
HBCS-5400/5500/6500		0.13 (0.005)		mm (in.)	
Scan Velocity	V_{SCAN}	7.6 (3)	127 (50)	cm/sec (in/sec)	
Contrast	R_W-R_B	45		%	1
Supply Voltage	V_S	4.5	5.5	Volts	2
Temperature	T_A	−20	+65	°C	
Ambient Light	E_V		100,000	lux	3
Tilt Angle	(See Figure 2)				
Orientation	(See Figure 3)				

NOTES:

1. Contrast is defined as R_W-R_B where R_W is the reflectance of the white spaces and R_B is the reflectance of the black bars, measured at the emitter wavelength (655 nm or 820 nm). Contrast is related to print contrast signal (PCS) by PCS = $(R_W\text{-}R_B)/R_W$ or $R_W\text{-}R_B$ = PCS*R_W.
2. Power supply ripple and noise should be less than 100 mV peak to peak.
3. Ambient light sources can be diffuse tungsten, sodium, mercury, fluorescent, sunlight, or a combination thereof.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	−40	+75	°C	
Operating Temperature	T_A	−20	+65	°C	
Supply Voltage	V_S	−0.5	+6.00	V	
Output Transistor Power	P_T		150	mW	
Output Collector Voltage	V_O	−0.5	+20	V	

Electrical Operation

The HBCS-5XXX/6XXX family of digital bar code wands consists of a precision optical sensor and an electronic circuit that creates a digital output of the bar code pattern. The open collector transistor requires only a pull-up resistor to provide a TTL compatible output from a single 4.5V to 5.5V DC power supply.

A non-reflecting black bar results in a logic high (1) level output, while a reflecting white space will cause a logic low (0) level output (see Figure 1). The initial state will be indeterminate. However, if no bar code is scanned, after a short period (typically less than 1 second), the wand will assume a logic low state. This feature insures that the first bar will not be missed in a normal scan.

The wands provide a case, cable and connector shield which must be terminated to logic ground or, preferably, to both logic ground and earth ground. The shield is connected to the metal housing of the 5 pin DIN connector.

All standard HP Low Current Digital Bar Code wands are certified to meet FCC Class B and VDE Level B standards. The shield must be properly terminated in order to maintain these approvals and to keep the cable from acting as an antenna, injecting electrical noise into the wand circuitry. Grounding the shield will also provide a substantial improvement in EMI/ESD immunity.

The recommended logic interface for the wands is shown in Figure 5. This interconnection provides the maximum ESD protection for both the wand and the user's electronics.

Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions	Notes
Supply Current	I_S		3.5	5.0	mA	$V_S = 5.0$ V	4, 5
High Level Output Current	I_{OH}			1.0	μA	$V_{OH} = 2.4$ V	
Low Level Output Voltage	V_{OL}			0.4	V	$I_{OL} = 16$ mA	
Output Rise Time	t_r		3.4	20	μs	10%-90% Transition $R_L = 1$ K	6
Output Fall Time	t_f		1.2	20	μs		6
Switch Bounce HBCS-5000/5200/5400	t_{sb}		0.5	5.0	ms		7
Electrostatic Discharge Immunity	ESD		25		kV		8
Wake-Up Time	t_w		50	200	ms		9

NOTES:

4. Push-to-read switch (if applicable) is depressed.
5. Not including pull-up resistor current.
6. See Figure 1.
7. Switch bounce causes a series of sub-millisecond pulses to appear at the output (V_O).
8. Shield must be properly terminated (see Figure 9). The human body is modeled by discharging a 300 pF capacitor through a 500 Ω resistor. No damage to the wand will occur at the specified discharge level.
9. After this time, the wand is operational.

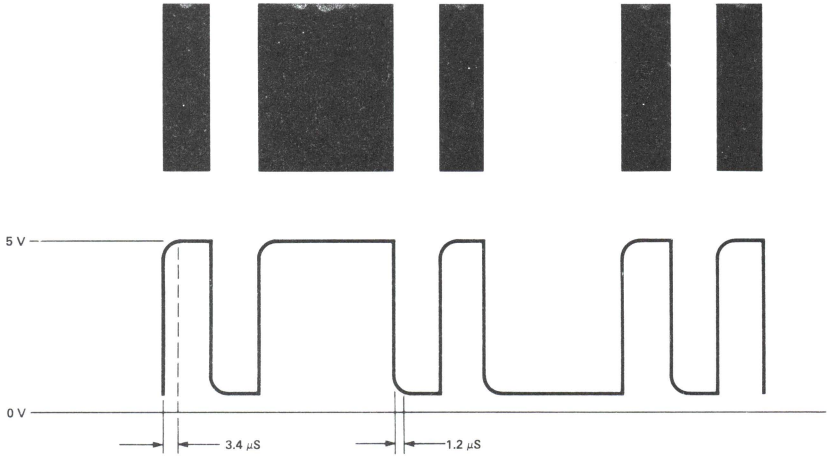


Figure 1. Typical Output Waveform

Depth of Field

Hewlett-Packard Digital Bar Code Wands are designed for contact scanning. However, it is possible to read through some overlay or covering material depending on the thickness of the material and the angle at which the wand is held. Figure 2 shows the relationship between tilt angle and depth of field.

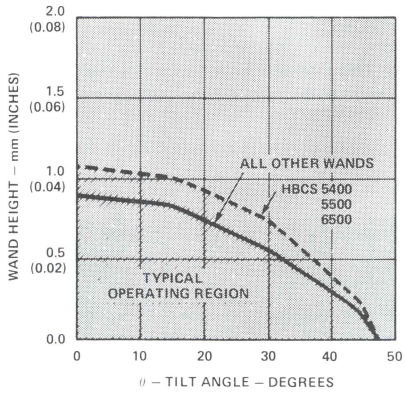


Figure 2. Wand Height vs. Tilt Angle

Testing

All Hewlett-Packard Digital Bar Code Wands are 100% tested for performance and digitizing accuracy after manufacture. This insures you of the consistent quality product you expect from HP. More information about our test procedures, test set-up, and test limits are available upon request.

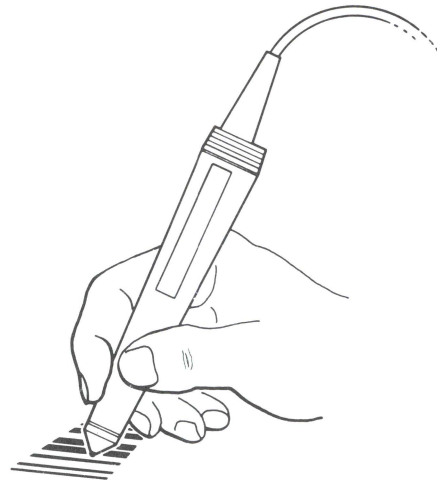


Figure 3. Preferred Orientation

Selection and Application Guide

	HBCS 5000	HBCS 5100	HBCS 5200	HBCS 5300	HBCS 5400	HBCS 5500	HBCS 6100	HBCS 6300	HBCS 6500
Wavelength (nm)	655	655	655	655	820	820	655	655	820
Nominal Narrow Element Width									
(mm)	0.33	0.33	0.19	0.19	0.13	0.13	0.33	0.19	0.13
(inch)	0.013	0.013	0.0075	0.0075	0.005	0.005	0.013	0.0075	0.005
Case Material									
Polycarbonate	X	X	X	X	X	X			
Metal							X	X	X
Switch	Yes	No	Yes	No	Yes	No	No	No	No
Will Read Bar Codes Printed Using:									
Regular Thermal Paper	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No
Dye-Based Inks	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No
Carbon Based Inks (Note 10)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Colors (Note 11)	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No
Best Choice For:									
Widest Range of Bar Code Printing			X	X				X	
Highest Resolution Printing					X	X			X
Low Resolution or Poor Quality Printing	X	X					X		

NOTES:

10. For "black-on-black" bar codes, use the infrared (820 nm) wands only.
11. For color bar codes the background (spaces) should reflect red light, and the bars should absorb red light.

Certification

FCC Certification (USA Only)

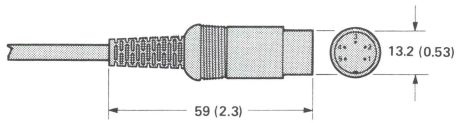
Model	FCC Identification
HBCS-6100 through -61XX	FCC ID: CUP6Z9HBCS-6100 HEWLETT—PACKARD
HBCS-6300 through -63XX	FCC ID: CUP6Z9HBCS-6300 HEWLETT—PACKARD
HBCS-6500 through -65XX	FCC ID: CUP6Z9HBCS-6500 HEWLETT—PACKARD
HBCS-5000 through -5XXX	FCC ID: CUP6Z9HBCS-5000 HEWLETT—PACKARD
HBCS-5100 through -51XX	FCC ID: CUP6Z9HBCS-5100 HEWLETT—PACKARD
HBCS-5200 through -52XX	FCC ID: CUP6Z9HBCS-5200 HEWLETT—PACKARD
HBCS-5300 through -53XX	FCC ID: CUP6Z9HBCS-5300 HEWLETT—PACKARD
HBCS-5400 through -54XX	FCC ID: CUP6Z9HBCS-5400 HEWLETT—PACKARD
HBCS-5500 through -55XX	FCC ID: CUP6Z9HBCS-5500 HEWLETT—PACKARD

This equipment generates radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference, However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

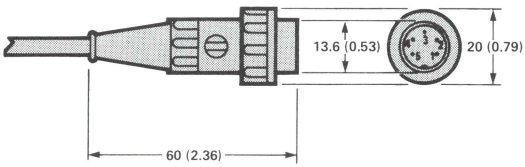
- Reorient the receiving antenna
- Relocate the wand with respect to the receiver
- Move the wand away from the receiver

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20422, Stock No. 004-00345-4.

Interface



HBCS-5XXX



HBCS-6XXX

NOTES:
1. DIMENSIONS IN MILLIMETRES AND (INCHES).

PIN	WIRE COLOR	FUNCTION
1	RED	V_S SUPPLY VOLTAGE
2	WHITE	V_O OUTPUT
3	BLACK	GROUND
4	N/A	N/C
5	N/A	N/C
CASE	-	SHIELD (MUST BE CONNECTED)

Figure 4. Connector Specifications.

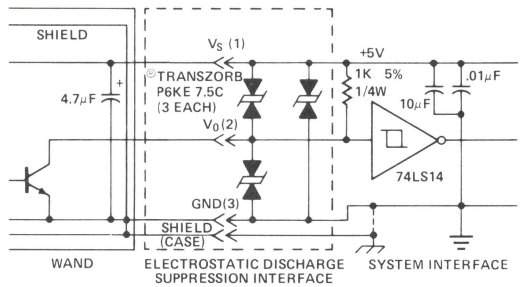


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Figure 5. Recommended Logic Interface (When earth ground is not available, connect shield to logic ground, as shown by dotted line).

The wands include a standard 5 pin, 240° DIN connector. The detailed specifications and pin-outs are shown in Figure 4. Mating connectors are available from RYE Industries and SWITCHCRAFT in both 5 pin and 6 pin configurations. These connectors are listed below.

Connector	Configuration
RYE MAB-5*	5 Pin
SWITCHCRAFT 61GA5F*	5 Pin
SWITCHCRAFT 61HA5F	5 Pin
RYE MAB-6*	6 Pin
SWITCHCRAFT 61HA6F	6 Pin

*Suitable for non-locking connector only.

Maintenance Considerations

There are no user serviceable parts inside the wand. The tip is designed to be easily replaceable, and if damaged it should be replaced. Before unscrewing the tip, disconnect the wand from the system power source. The part number for the wand tip is HBCS-2999 for the HBCS-5XXX family and HBCS-4999 for the HBCS-6XXX family. The tips can be ordered from any Hewlett-Packard authorized distributor.

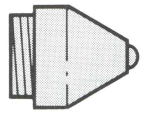


Figure 6A. HBCS-2999 Sapphire Tip

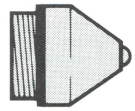


Figure 6B. HBCS-4999 Sapphire Tip

Optional Features

For options such as special cords, connectors or labels, contact your nearest Hewlett-Packard sales office or authorized representative.

Wand Dimensions

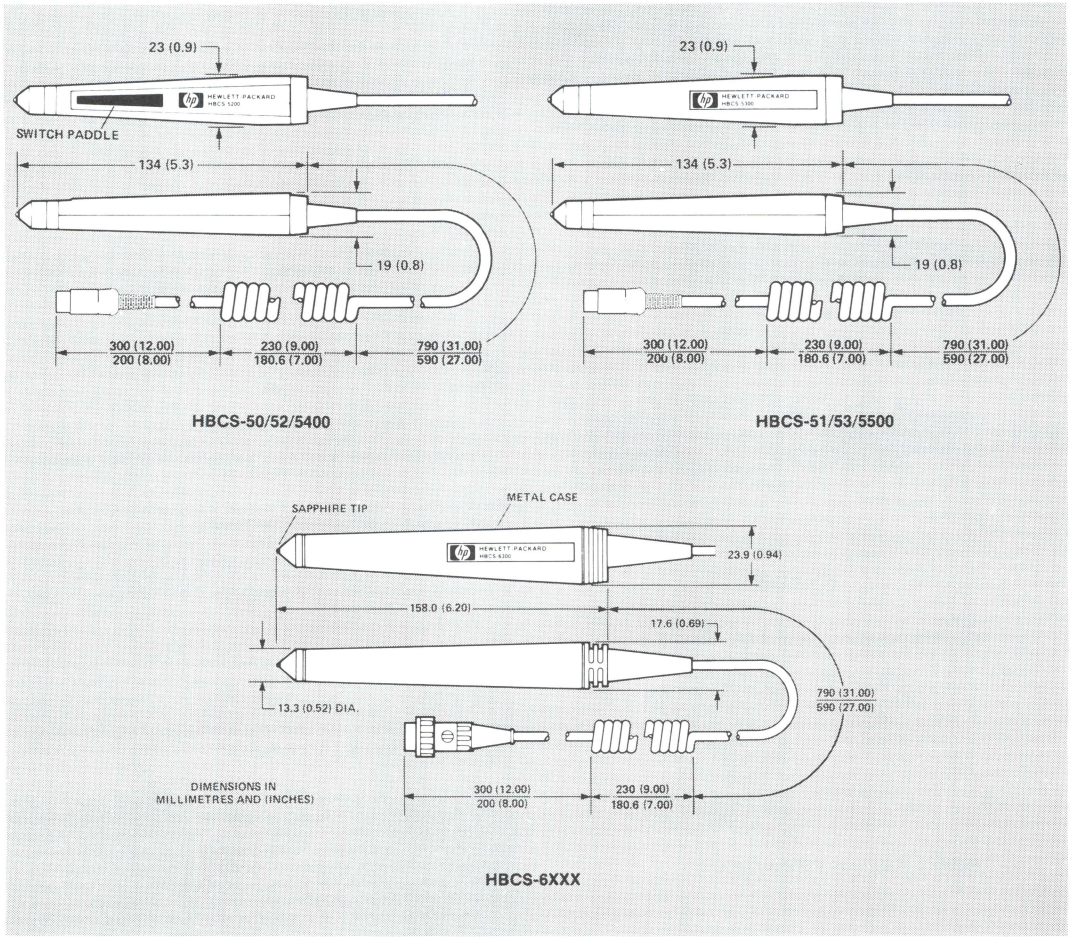


Figure 7.

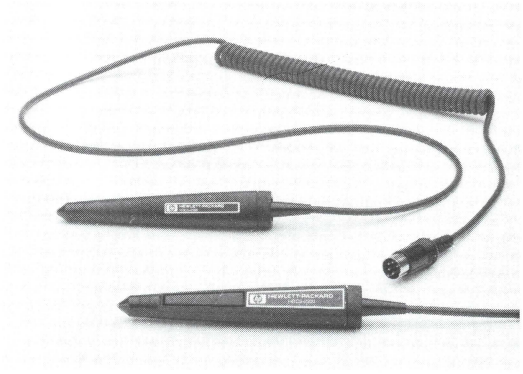
HEWLETT PACKARD

SAPPHIRE TIP DIGITAL BAR CODE WANDS

HBCS-2200
HBCS-2300
HBCS-2400
HBCS-2500

Features

- **SCAN ANGLE 0 TO 45 DEGREES**
- **OPERATING TEMPERATURE −20° C TO +65° C**
- **AVAILABLE IN EITHER 0.19 mm (0.0075 IN.) OR 0.13 0.13 mm (0.005 IN.) RESOLUTION**
- **SEALED REPLACEABLE SAPPHIRE TIP**
  Provides Protection from Contamination Due to Dirt and Debris
- **DIGITAL OUTPUT**
  Open Collector Output Compatible with TTL and CMOS
- **DECODABILITY SPECIFIED FOR GUARANTEED PERFORMANCE**
- **SINGLE 5 VOLT SUPPLY**
- **PUSH-TO-READ SWITCH (HBCS-2200/2400)**
  Minimizes Power Consumption in Battery Operated Systems
- **SOLID STATE RELIABILITY**
- **POLYCARBONATE CASE**
  Durable, yet Lightweight



Description

Hewlett-Packard's Sapphire Tip Digital Bar Code Wands are hand-held scanners optimized to provide excellent reading of all common bar code formats. These wands contain an optical sensor with a 700 nm visible red LED (HBCS-2200/2300) or an 820 nm infrared LED (HBCS-2400/2500); a photo IC detector; and precision aspheric optics. The internal signal conditioning circuitry converts the optical information into a logic level pulse width representation of the bars and spaces.

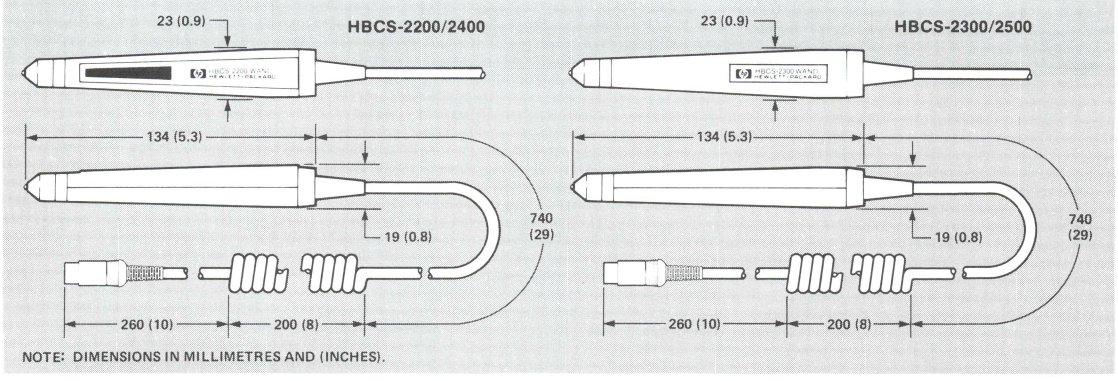
The HBCS-2200/2300 wands, with their nominal 0.19 mm spot size, are excellent choices for reading a general range of bar codes. The HBCS-2400/2500 wands have a nominal spot size of 0.13 mm and are ideal for reading very high density bar code.

All of the wands feature an internal shield for maximizing immunity to electromagnetic interference (EMI), electrostatic discharge (ESD), and ground loops. The shield is also designed to eliminate noise from capacitively coupled inputs.

The HBCS-2200 and HBCS-2400, with their push-to-read switch, are recommended for use in battery powered applications requiring low power consumption. The HBCS-2300 and HBCS-2500 (without switch) are the usual choices for AC powered systems.

The standard wand configuration includes a strain relieved coiled cord, which has a comfortable extended length of 190 cm (75 in.). Maximum length is 250 cm (100 in.). The standard connector is a 5 pin, 240 degree DIN connector.

Wand Dimensions



NOTE: DIMENSIONS IN MILLIMETRES AND (INCHES).

Applications

The digital bar code wand is a highly effective alternative to keyboard data entry. Bar code scanning is faster and more accurate than key entry and provides far greater throughput. In addition, bar code scanning typically has a higher first read rate and greater data accuracy than optical character recognition. When compared to magnetic stripe encoding, bar code offers significant advantages in flexibility of media, symbol placement and immunity to electromagnetic fields.

Hewlett-Packard's sapphire tip wands are designed for use in applications where dirt and debris are a common occurrence and could cause clogging in a conventional open-tip wand. In addition, the sapphire ball provides superior wear resistance and improves scanning ease. The rugged yet lightweight polycarbonate case makes these wands ideal for use in commercial or light industrial applications.

Applications include remote data collection, work-in-process tracking, point-of-sale data entry, inventory control, library circulation control, medical records tracking, and repair/service work.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Notes
Nominal Narrow Element Width					
HBCS-2200/2300		0.19 (0.0075)		mm (in.)	
HBCS-2400/2500		0.13 (0.005)		mm (in.)	
Scan Velocity	V_{SCAN}	7.6 (3)	127 (50)	cm/sec (in/sec)	
Contrast	R_W-R_B	45		%	1
Supply Voltage	V_S	4.5	5.5	Volts	2
Temperature	T_A	−20	+65	°C	
Tilt Angle	(See Figure 8)				3
Orientation	(See Figure 1)				

Notes:

1. Contrast is defined as R_W-R_B, where R_W is the reflectance of the white spaces and R_B is the reflectance of the black bars, measured at the emitter wavelength (700 nm or 820 nm). Contrast is related to print contrast signal (PCS) by PCS = (R_W-R_B)/R_W or R_W-R_B = PCS*R_W.
2. Power supply ripple and noise should be less than 100 mV peak to peak.
3. Performance in sunlight will vary depending on shading at wand tip.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	−40	+75	°C	
Operating Temperature	T_A	−20	+65	°C	
Supply Voltage					
HBCS-2200/2300	V_S	−0.5	+6.00	V	
HBCS-2400/2500	V_S	−0.5	+5.75	V	
Output Transistor Power	P_T		200	mW	
Output Collector Voltage	V_O	−0.5	+20	V	

Electrical Operation

The HBCS-2XXX family of digital bar code wands consists of a precision optical sensor, an analog amplifier, a digitizing circuit, and an output transistor. These elements provide a TTL compatible output from a single 4.5V to 5.5V power supply. The open collector transistor requires an external pull-up resistor for proper operation.

A non-reflecting black bar results in a logic high (1) level output, while a reflecting white space will cause a logic low (0) level output. The initial or "wake-up" state will be indeterminate. However, after a short period (typically less than 1 second), the wand will assume a logic low state if no bar code is scanned. This feature insures that the first bar will not be missed in a normal scan.

The wands provide a case, cable, and connector shield which must be terminated to logic ground or, preferably, to both logic ground and earth ground. The shield is connected to the metal housing of the 5 pin DIN connector.

Grounding the shield will provide a substantial improvement in EMI/ESD immunity in AC powered systems. However, it is essential that the shield be properly terminated even when EMI and ESD are not a concern, otherwise the shield will act as an antenna, injecting electrical noise into the wand circuitry.

The HBCS-2200/2400 wands incorporate a push-to-read switch which is used to energize the LED emitter and electronic circuitry. When the switch is initially depressed, contact bounce may cause a series of random pulses to appear at the output (V_O). This pulse train will typically settle to a final value within 5 ms.

The recommended logic interface for the wands is shown in Figure 9. This interconnection provides the maximum ESD protection for both the wand and the user's electronics.

Electrical Characteristics

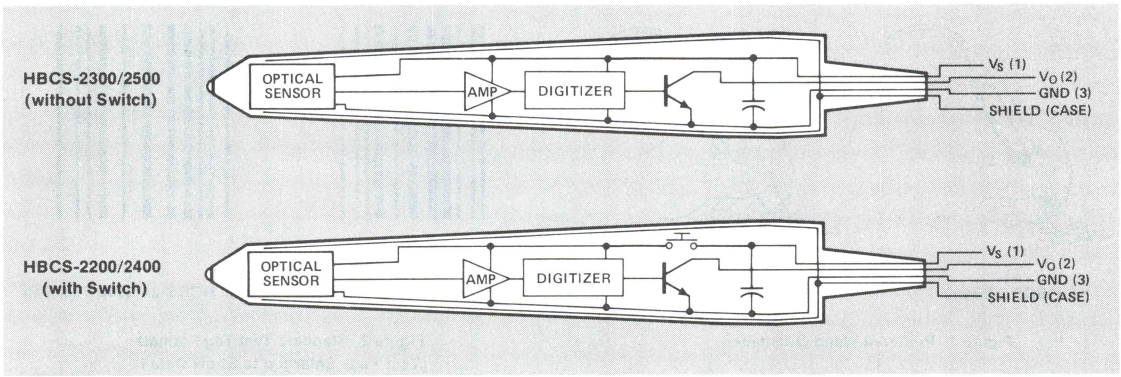
(V_S = 4.5V to 5.5V, T_A = 25° C, R_L = 1KΩ to 10KΩ, unless otherwise noted)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions	Notes
Supply Current	I_S		42	50	mA	V_S = 5.0V	4
High Level Output Current	I_{OH}			400	μA	V_{OH} = 2.4V	
Low Level Output Voltage	V_{OL}			0.4	V	I_{OL} = 16 mA	
Output Rise Time	t_r		3.4	20	μs	10%-90% Transition R_L = 1K	
Output Fall Time	t_f		1.2	20	μs		
Switch Bounce HBCS-2200/2400	t_{sb}		0.5	5.0	ms		5
Electrostatic Discharge Immunity	ESD		25		kV		6

Notes:

4. Push-to-read switch (if applicable) is depressed.
5. Switch bounce causes a series of sub-millisecond pulses to appear at the output (V_O).
6. Shield must be properly terminated (see Figure 9). The human body is modeled by discharging a 300 pF capacitor through a 500 Ω resistor. No damage to the wand will occur at the specified discharge level.

Block Diagram



Scanning Performance

(V_S = 5.0 V, R_L = 1.0 to 10 KΩ, T_A = 25° C, Scan Velocity = 50 cm/sec)

Parameter	Symbol	HBCS-	Typ.	Max.	Units	Condition	Fig.	Note
Decodability Index	DI	2200/2300	9	22	%	Tilt Angle 0° to 40° Preferred Orientation Standard Test Tag	1,2,3 4,7,9	7,8
		2400/2500	12	22	%			
Average Width Error (Narrow Bars)	OS_{bn}	2200/2300	0.005 (0.0002)		mm (in.)		1,2,9	7
		2400/2500	0.024 (0.0009)		mm (in.)			
Average Width Error (Wide Bars)	OS_{bw}	2200/2300	0.003 (0.0001)		mm (in.)			
		2400/2500	0.023 (0.009)		mm (in.)			
Average Width Error (Narrow Spaces)	OS_{sn}	2200/2300	−0.011 (−0.0004)		mm (in.)			
		2400/2500	−0.027 (−0.0106)		mm (in.)			
Average Width Error (Wide Spaces)	OS_{sw}	2200/2300	−0.002 (−0.0001)		mm (in.)			
		2400/2500	−0.026 (−0.0010)		mm (in.)			
Deviation from Average (Internal)	d_e	2200/2300	0.018 (0.0007)	0.048 (0.0019)	mm (in.)		1,2,5 6,9	7
		2400/2500	0.019 (0.0007)	0.052 (0.0020)	mm (in.)			
Deviation from Average (First Bar)	db_1	2200/2300	0.090 (0.0035)	0.152 (0.0060)	mm (in.)			
		2400/2500	0.060 (0.0024)	0.100 (0.0039)	mm (in.)			

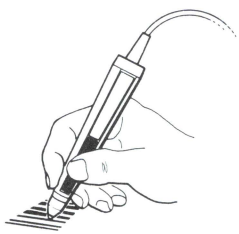
Notes:

7. The test tag for the HBCS-2200/2300 Wands (Figure 2a) consists of black bars and white spaces with a narrow element width of 0.19 mm (0.0075 in.) and a wide element width of 0.42 mm (0.0165 in.). This equates to a wide-to-narrow ratio of 2.2:1. A margin, or white reflecting area, of at least 5 mm in width precedes the first bar.

   The test tag for the HBCS-2400/2500 wands (Figure 2b) consists of black bars with a narrow element width of 0.13 mm (0.005 in.) and wide element width of 0.43 mm (0.017 in.), giving a ratio of 3.4:1. The white spaces have a narrow element width of 0.28 mm (0.011 in.) and wide element width of 0.64 mm (0.025 in.) yielding a ratio of 2.3:1. Both tags are photographically reproduced on diffuse reflecting paper with a PCS greater than 90%.

8. Decodability index is a measure of the errors produced by the wand when scanning a standard test symbol at a constant velocity. It is expressed as a percentage of the narrow element width.

   For a more detailed discussion of the terms used here, see Hewlett-Packard Application Note 1013 "Elements of a Bar Code System" (publication number 5953-9387).

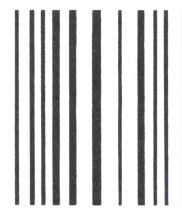


HBCS-22/2400

HBCS-23/2500

Figure 1. Preferred Wand Orientation

a. HBCS-22/2300 Test Tag



b. HCBS-24/2500 Test Tag

Figure 2. Standard Test Tag Formats (Test Tags Enlarged to Show Detail)

Typical Performance Curves

(V_S = 5 V, R_L = 1 KΩ, T_A = 25° C, Tilt = 15°, V_{SCAN} = 50 cm/sec unless otherwise specified)

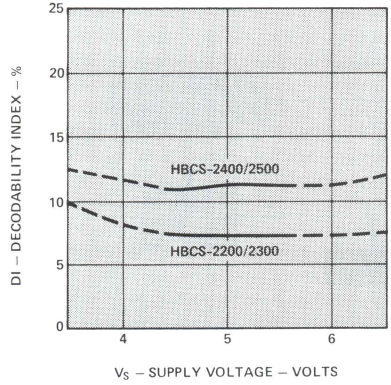


Figure 3. Decodability Index vs. Supply Voltage.

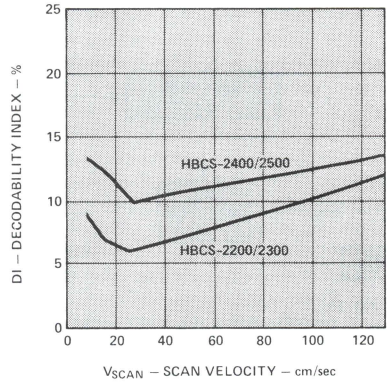


Figure 4. Decodability Index vs. Scan Velocity.

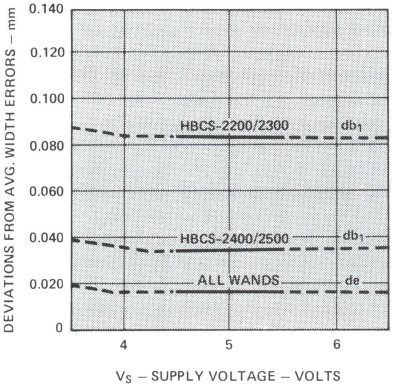


Figure 5. Deviation from Average Width Error vs. Supply Voltage.

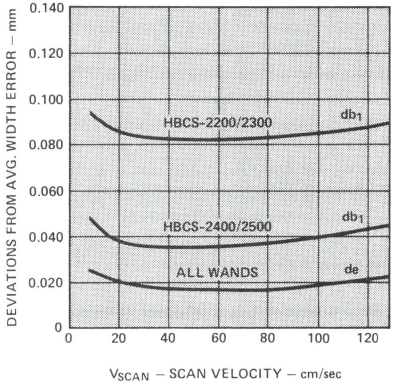


Figure 6. Deviation from Average Width Error vs. Scan Velocity.

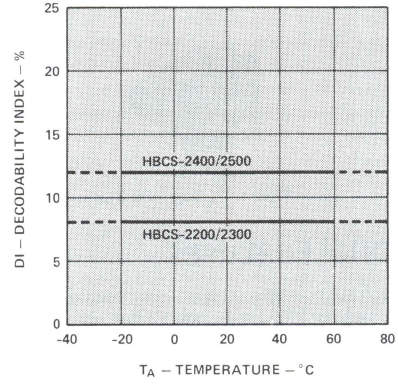


Figure 7. Decodability Index vs. Temperature.

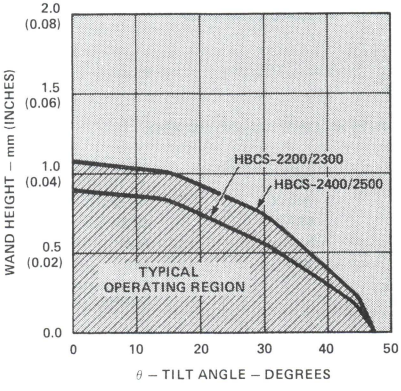
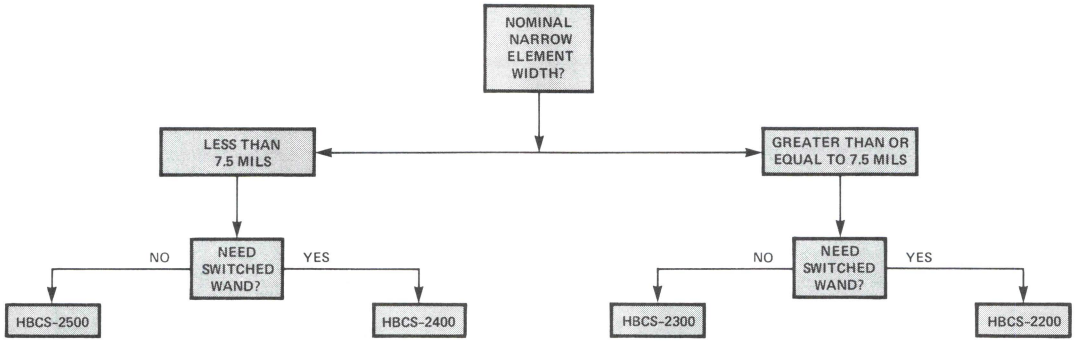


Figure 8. Wand Height vs. Tilt Angle.

Selection Guide



NOTES:
IF IT IS NECESSARY TO READ BAR CODE PRINTED IN COLORS OTHER THAN BLACK AND WHITE IT IS RECOMMENDED THAT EITHER THE HBCS-2200 OR HBCS-2300 WANDS BE SELECTED.

IF IT IS NECESSARY TO READ SECURITY "BLACK-ON-BLACK" BAR CODE (CARBON-BASED BLACK AND WHITE BAR CODE WITH A BLACK OVERLAY), IT IS RECOMMENDED THAT EITHER THE HBCS-2400 OR THE HBCS-2500 WANDS BE SELECTED.

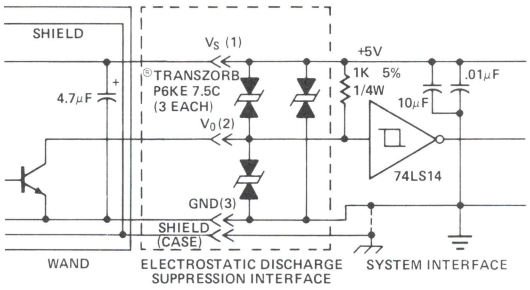


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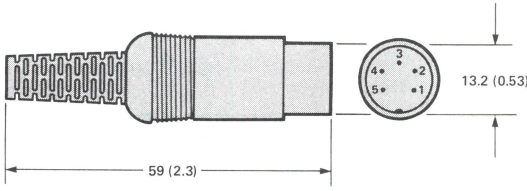
Figure 9. Recommended Logic Interface (When earth ground is not available, connect shield to logic ground, as shown by dotted line).



NOTES:
1. DIMENSIONS IN MILLIMETRES AND (INCHES).

PIN	WIRE COLOR	FUNCTION
1	RED	V_S SUPPLY VOLTAGE
2	WHITE	V_O OUTPUT
3	BLACK	GROUND
4	N/A	N/C
5	N/A	N/C
CASE	-	SHIELD (MUST BE CONNECTED)

Figure 10. Connector Specifications.

Mechanical Considerations

The wands include a standard 5 pin, 240° DIN connector. The detailed specifications and pin-outs are shown in Figure 10. Mating connectors are available from RYE Industries and SWITCHCRAFT in both 5 pin and 6 pin configurations. These connecors are listed below.

Connector	Configuration
RYE MAB-5	5 Pin
SWITCHCRAFT 61GA5F	5 Pin
SWITCHCRAFT 61HA5F	5 Pin
RYE MAB-6	6 Pin
SWITCHCRAFT 61GA6F	6 Pin

Maintenance Considerations

There are no user serviceable parts inside the wand. The tip is designed to be easily replaceable, and if damaged it should be replaced. Before unscrewing the tip, disconnect the wand from the system power source. The part number for the wand tip is HBCS-2999. The tip can be ordered from any Hewlett-Packard franchised distributor.

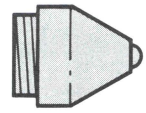


Figure 11. Sapphire Tip.

Optional Features

For options such as special cords, connectors or labels, contact your nearest Hewlett-Packard sales office or franchised Hewlett-Packard distributor.

HEWLETT PACKARD

DIGITAL BAR CODE WAND

HEDS-3000
HEDS-3050

Features

- **0.3 mm RESOLUTION**
  Enhances the Readability of dot matrix printed bar codes
- **DIGITAL OUTPUT**
  Open Collector Output Compatible with TTL and CMOS
- **PUSH-TO-READ SWITCH (HEDS-3000)**
  Minimizes Power in Battery Operated Systems
- **SINGLE 5V SUPPLY OPERATION**
- **ATTRACTIVE, HUMAN ENGINEERED CASE**
- **DURABLE LOW FRICTION TIP**
- **SOLID STATE RELIABILITY**
  Uses LED and IC Technology
- **SHIELDED CASE AND CABLE (HEDS-3050)**
  Maximizes EMI/ESD Immunity in AC Powered Systems

Description

The HEDS-3000 and HEDS-3050 Digital Bar Code Wands are hand held scanners designed to read all common bar code formats that have the narrowest bars printed with a nominal width of 0.3 mm (0.012 in.). The wands contain an optical sensor with a 700 nm visible light source, photo IC detector, and precision aspheric optics. Internal signal conditioning circuitry converts the optical information into a logic level pulse width representation of the bars and spaces.

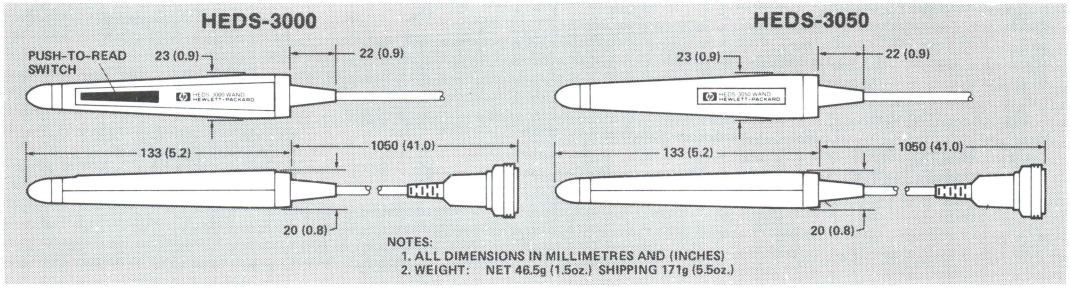
The HEDS-3000 comes equipped with a push-to-read switch which is used to activate the electronics in battery powered applications requiring lowest power consumption. The HEDS-3050 does not have a switch, and features internal metal shielding that maximizes immunity to electromagnetic interference, electrostatic discharge, and ground loops in AC powered systems. Both wands feature a strain relieved 104 cm (41 in.) cord with a nine-pin subminiature D-style connector.

Applications

The Digital Bar Code Wand is an effective alternative to the keyboard when used to collect information in self-contained blocks. Bar code scanning is faster than key entry and also more accurate since most codes have check-sums built-in to prevent incorrect reads from being entered.

Applications include remote data collection, ticket identification systems, security checkpoint verification, file folder tracking, inventory control, identifying assemblies in service, repair, and manufacturing environments, and programming appliances, intelligent instruments and personal computers.

Wand Dimensions



Electrical Operation

The HEDS-3000 and HEDS-3050 consist of a precision optical sensor, an analog amplifier, a digitizing circuit, and an output transistor. These elements provide a TTL compatible output from a single voltage supply range of 3.6V to 5.75V. A non-reflecting black bar results in a logic high (1) level, while a reflecting white space will cause a logic low (0) at the V_O connection (pin 2). The output of the wands is an open collector transistor.

The HEDS-3050 provides a case and cable shield (pin 5) which must be connected to logic ground and preferably also to earth ground. This will provide a substantial improvement in EMI/ESD immunity for the wand in AC powered systems.

The recommended logic interface for the wands is shown in Figure 3. This interconnection provides maximum ESD protection for both the wand and the user's electronics.

The HEDS-3000 incorporates a push-to-read switch which is used to energize the 700nm LED emitter and electronic circuitry. When the switch is initially depressed, its contact bounce may cause a series of random pulses to appear at the output, V_O. This pulse train will typically settle to a final value within 0.5 ms. This initial pulse train is eliminated when a switchless HEDS-3050 is used.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Bar Width	s, b	0.3		mm
Scan Velocity	V_{scan}	7.6	76	cm/s
Contrast	PCS	70		%
Supply Voltage	V_S	3.6	5.75	V
Temperature	T_A	0	55	°C
Orientation	See Figure 1			

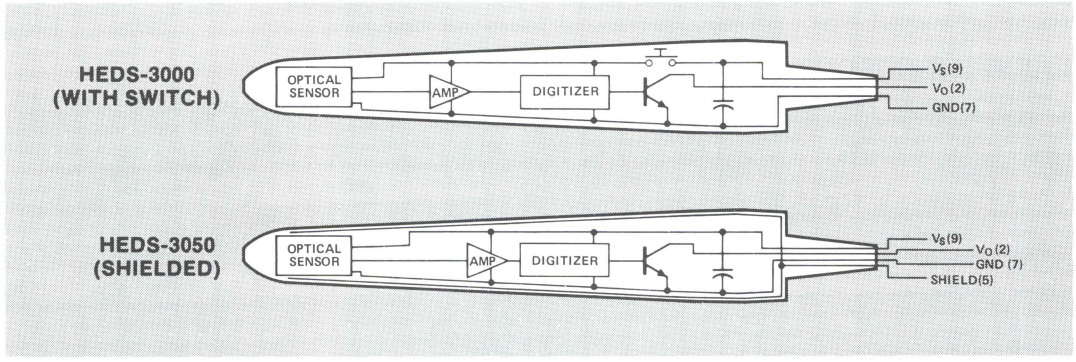
Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	-20	55	°C	1
Operating Temperature	T_A	0	55	°C	
Supply Voltage	V_S	-0.5	6.0	V	2
Output Transistor Power	P_T		200	mW	
Output Collector Voltage	V_O		20	V	

Electrical Characteristics (V_S = 3.6V to 5.75V at T_A = 25°C, R_L = 2.2kΩ, unless otherwise noted)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions	Fig.	Notes
Switch Bounce (HEDS-3000)	t_{sb}		0.5	5	ms			3
High Level Output Current	I_{OH}			400	μA	V_{OH} = 2.4V, Bar Condition (Black)	3	
Low Level Output Voltage	V_{OL}			0.4	V	I_{OL} = 16mA, Space Condition (White)	3	
Output Rise Time	t_r		2		μs	10%-90% Transition	3	
Output Fall Time	t_f		100		ns	90%-10% Transition	3	
Supply Current	I_S		42	50	mA	V_S = 5V, Bar Condition (Black)		2,4

Block Diagram



GUARANTEED WIDTH ERROR PERFORMANCE

(V_S = 5V, T_A = 0°C to 55°C, R_L = 2.2kΩ, unless otherwise noted)

Parameter		Symbol	Min.	Typ.	Max.	Units	Conditions		Fig.	Notes
Bar Width Error	1st	Δb_1		0.08 (3.2)	0.13 (5.2)	mm (in.x10^{-3})	T_A=25°C	Margin ≥ 5mm Height = 0.25mm Tilt = 0° v_{scan} = 50 cm/s Standard Test Tag Preferred Orientation b=s=0.3mm (0.012 in.) 2b=2s=0.6mm (0.024 in.)	1 2,6 11	5 7,8 9,10 11
				0.10 (3.8)	0.15 (5.7)		T_A = 0° to 55°C			
	Interior	Δb	-0.04 (-1.4)	0.05 (1.8)	0.10 (3.9)	mm (in.x10^{-3})	T_A=25°C		1,2 6,11	6,7 8,9 10,11
			-0.05 (-2.0)	0.05 (2.0)	0.11 (4.3)		T_A = 0° to 55°C			
Space Width Error	Interior	Δs	0.04 (1.4)	-0.05 (-1.8)	-0.10 (-3.9)	mm (in.x10^{-3})	T_A=25°C		1,2 6,11	6,7 8,10 11
			0.05 (2.0)	-0.05 (-2.0)	-0.11 (-4.3)		T_A = 0° to 55°C			
Tag Scan Velocity		v_{scan}	7.6		76	cm/s			9	7
Emitter Peak Wavelength		λ		700		nm	T_A=25°C			

TYPICAL WIDTH ERROR PERFORMANCE (V_S = 5V, T_A = 25°C, R_L = 2.2kΩ, unless otherwise noted)

Parameter			Symbol	Typical WE Tilt = 0° Height = 0.25mm	Typical WE Tilt = 30° Height = 0.0mm	Units	Conditions	Fig.	Notes
Bar Width Error	From	To	Δb_1	0.08 (3.2)	0.11 (4.2)	mm (in.x10^{-3})	Margin ≥ 5mm 1b=1s=0.3mm 2b=2s=0.6mm T_A=25°C V_S=5V v_{scan}=50cm/s Preferred Orientation Standard Test Tag	1,2	5,7,8
	Margin	1st							
	1s	1b	Δb_{1-1}	0.03 (1.2)	0.04 (1.6)	mm (in.x10^{-3})		1,2	6,7,8
	2s	1b	Δb_{2-1}	0.06 (2.5)	0.07 (2.9)	mm (in.x10^{-3})		1,2	6,7,8
	1s	2b	Δb_{1-2}	0.02 (0.9)	0.02 (0.7)	mm (in.x10^{-3})		1,2	6,7,8
	2s	2b	Δb_{2-2}	0.05 (1.9)	0.05 (2.1)	mm (in.x10^{-3})		1,2	6,7,8
Space Width Error	1b	1s	Δs_{1-1}	-0.04 (-1.4)	-0.04 (-1.4)	mm (in.x10^{-3})		1,2	6,7,8
	2b	1s	Δs_{2-1}	-0.03 (-1.0)	-0.03 (-1.1)	mm (in.x10^{-3})		1,2	6,7,8
	1b	2s	Δs_{1-2}	-0.07 (-2.7)	-0.08 (-3.3)	mm (in.x10^{-3})		1,2	6,7,8
	2b	2s	Δs_{2-2}	-0.06 (-2.4)	-0.06 (-2.4)	mm (in.x10^{-3})		1,2	6,7,8

Notes:
1. Storage Temperature is dictated by Wand case.
2. Power supply ripple and noise should be less than 100 mV.
3. Switch bounce causes a series of sub-millisecond pulses to appear at the output, V_O. (HEDS-3000 only)
4. Push-to-Read switch is depressed, and the Wand is placed on a non-reflecting (black) surface. (HEDS-3000 only)
5. The margin refers to the reflecting (white) space that preceeds the first bar of the bar code.
6. The interior bars and spaces are those which follow the first bar of bar code tag.
7. The standard test tag consists of black bars, white spaces (0.3 mm, 0.012 in. min.) photographed on Kodagraph Transtar TC5® paper with a print contrast signal greater than 0.9.
8. The print contrast signal (PCS) is defined as: PCS = (R_w - R_b) /R_w, where R_w is the reflectance at 700 nm from the white spaces, and R_b is the reflectance at 700 nm for the bars.
9. 1.0 in. = 25.4 mm, 1 mm = 0.0394 in.
10. The Wand is in the preferred orientation when the surface of the label is parallel to the height dimension of the bar code.

OPERATION CONSIDERATIONS

The Wand resolution is specified in terms of a bar and space Width Error, WE. The width error is defined as the difference between the calculated bar (space) width, B, (S), and the optically measured bar (space) widths, b (s). When a constant scan velocity is used, the width error can be calculated from the following.

$B = t_b \cdot v_{scan}$

$S = t_s \cdot v_{scan}$

$\Delta b = B - b$

$\Delta s = S - s$

Where

Δb, Δs= bar, space Width Error (mm)

b, s = optical bar, space width (mm)

B, S = calculated bar, space width (mm)

v_{scan} = scan velocity (mm/s)

t_b, t_s = wand pulse width output(s)

The magnitude of the width error is dependent upon the width of the bar (space) preceeding the space (bar) being measured. The Guaranteed Width Errors are specified as a maximum for the margin to first bar transition, as well as, maximums and minimums for the bar and space width errors resulting from transitions internal to the body of the bar code character. The Typical Width Error Performance specifies all possible transitions in a two level code (e.g. 2 of 5). For example, the $\Delta b_{2\to1}$ Width Error specifies the width error of a single bar module (0.3 mm) when preceeded by a double space module (0.6 mm).

The Bar Width Error Δb, typically has a positive polarity which causes the calculated bar, B, to appear wider than its printed counterpart. The typical negative polarity of the Space Width Error Δs, causes the measured spaces to appear narrower. The consistency of the polarity of the bar and space Width Errors suggest decoding schemes which average the measured bars and measured spaces within a character. These techniques will produce a higher percentage of good reads.

The Wand will respond to a bar code with a nominal module width of 0.3 mm when it is scanned at tilt angles between 0° and 30°. The optimum performance will be obtained when the Wand is held in the preferred orientation (Figure 1), tilted at an angle of 10° to 20°, and the Wand tip is in contact with the tag. The Wand height, when held normal to the tag, is measured from the tip's aperture, and when it is tilted it is measured from the tip's surface closest to the tag. The Width Error is specified for the preferred orientation, and using a Standard Test Tag consisting of black bars and white spaces. Figure 2 illustrates the random two level bar code tag. The Standard Test Tag is photographed on Kodagraph Transtar TC5® paper with a nominal module width of 0.3 mm (0.012 in.) and a Print Contrast Signal (PCS) of greater than 90%.

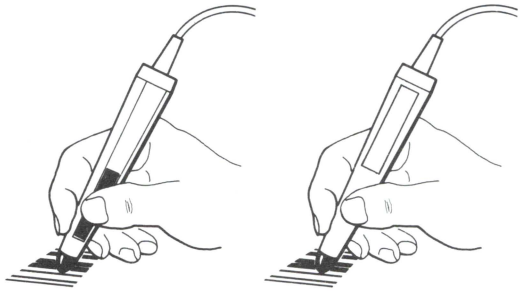


Figure 1. Preferred Wand Orientation.

BAR WIDTH 0.3 mm (0.012 in.) BLACK & WHITE

$R_{WHITE} \geq 75\%$, PCS $\geq$ 0.9 KODAGRAPH TRANSTAR TC5® PAPER

Figure 2. Standard Test Tag Format.

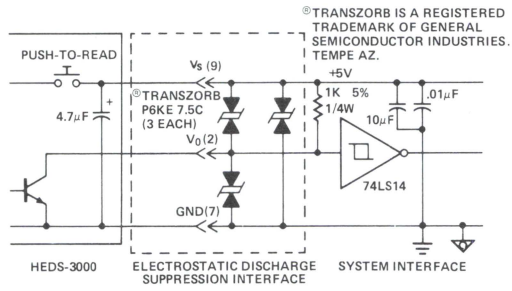


Figure 3a. Recommended Logic Interface for HEDS-3000

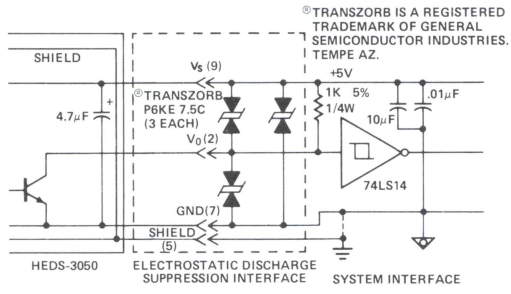


Figure 3b. Recommended Logic Interface for HEDS-3050. (When earth ground is not available, connect shield to logic ground, as shown by dotted line)

Typical Performance Curves (R_L = 2.2kΩ)

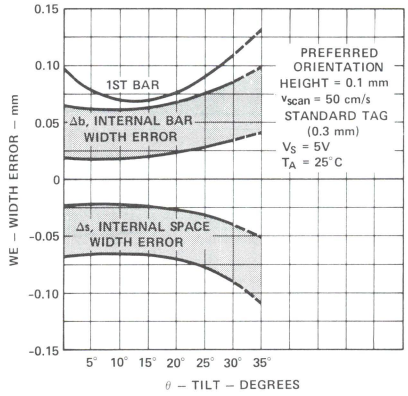


Figure 4. Width Error vs. Tilt (Preferred Orientation).

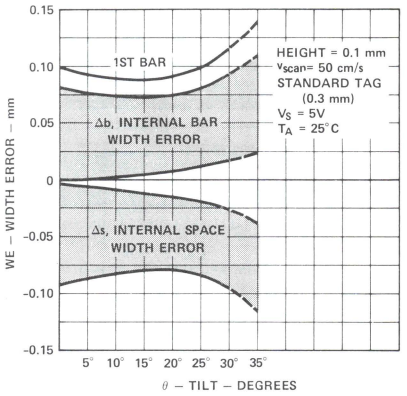


Figure 5. Width Error vs. Tilt (Any Orientation).

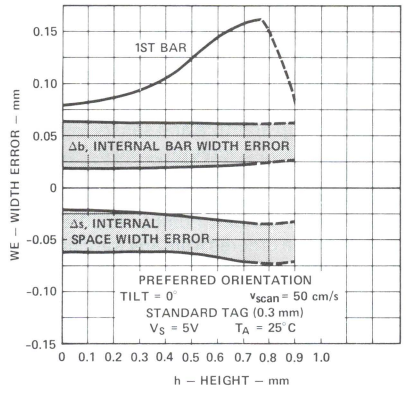


Figure 6. Width Error vs. Height (Preferred Orientation).

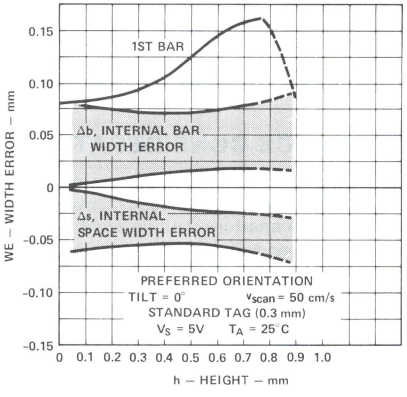


Figure 7. Width Error vs. Height (Any Orientation).

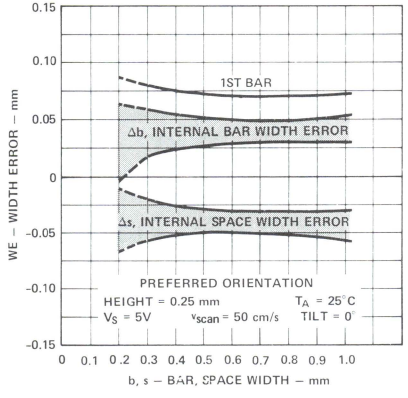


Figure 8. Width Error vs. Bar Width.

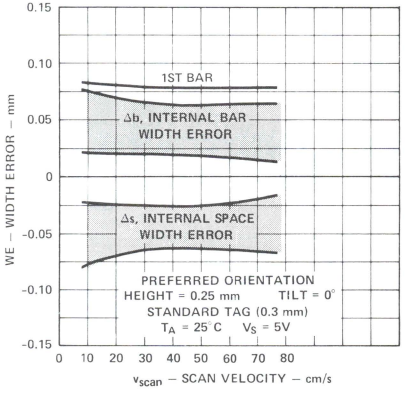


Figure 9. Width Error vs. Scan Velocity.

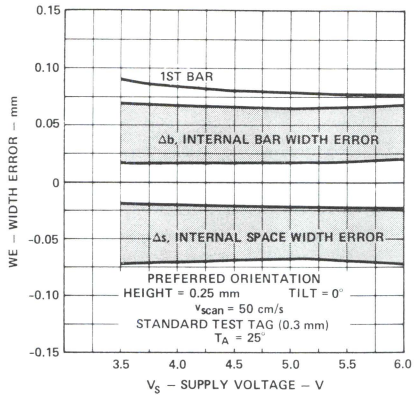


Figure 10. Width Error vs. Supply Voltage.

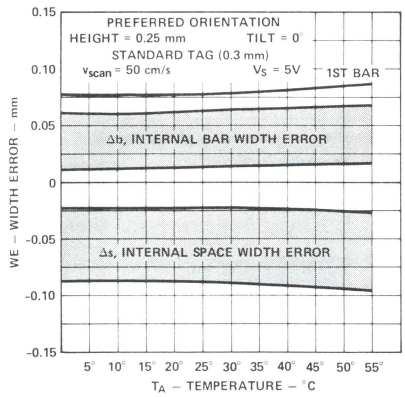


Figure 11. Width Error vs. Temperature.

MECHANICAL CONSIDERATIONS

The HEDS-3000/-3050 include a standard nine pin D-style connector with integral squeeze-to-release retention mechanism. Two types of receptacles with the retention mechanism are available from AMP Corp. (Printed circuit header: 745001-2 Panel mount: 745018, body; 66570-3, pins). Panel mount connectors that are compatible with the Wand connector, but do not include the retention mechanism, are the Molex A7224, and AMP 2074-56-2.

MAINTENANCE CONSIDERATIONS

While there are no user serviceable parts inside the Wand, the tip should be checked periodically for wear and dirt, or obstructions in the aperture. The tip aperture is designed to reject particles and dirt but a gradual degradation in performance will occur as the tip wears down, or becomes obstructed by foreign materials.

Before unscrewing the tip, disconnect the Wand from the system power source. The aperture can be cleaned with a cotton swab or similar device and a liquid cleaner.

The glass window on the sensor should be inspected and cleaned if dust, dirt, or fingerprints are visible. To clean the sensor window dampen a lint free cloth with a liquid cleaner, then clean the window with the cloth taking care not to disturb the orientation of the sensor. DO NOT SPRAY CLEANER DIRECTLY ON THE SENSOR OR WAND.

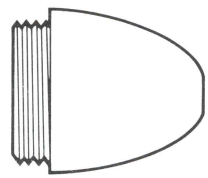


Figure 12. Wand Tip.

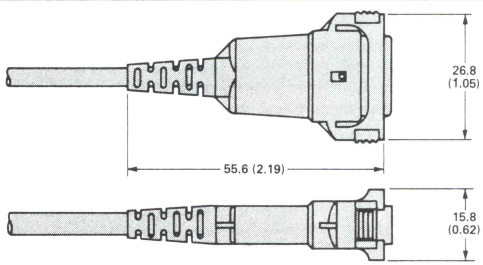
After cleaning the tip aperture and sensor window, the tip should be gently and securely screwed back into the Wand assembly. The tip should be replaced if there are visible indications of wear such as a disfigured, or distorted aperture. The part number for the Wand tip is HEDS-3001. It can be ordered from any franchised Hewlett-Packard distributor.

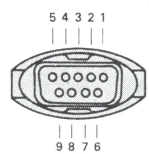
OPTIONAL FEATURES

The wand may also be ordered with the following special features:

- Special colors
- Customer specified label
- No label
- Heavy duty retractable coiled cord
- No connector
- With/without switch button

For more information, call your local Hewlett-Packard sales office or franchised distributor.





Pin	Wire Color	HEDS-3000 Function	HEDS-3050 Function
1	NC	NC	NC
2	White	V_O Output	V_O Output
3	NC	NC	NC
4	NC	NC	NC
5	—	NC	Shield
6	NC	NC	NC
7	Black	Ground	Ground
8	NC	NC	NC
9	Red	V_S Supply Voltage	V_S Supply Voltage

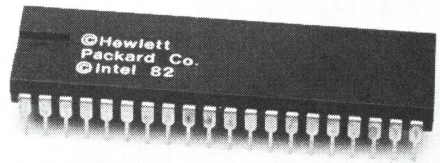
Figure 13. Connector Specifications.

HEWLETT PACKARD

BAR CODE DECODER IC | HBCR-1800

Features

- **INDUSTRY STANDARD BAR CODES**
  - **3 of 9 Code**
  - **Extended 3 of 9 Code**
  - **Interleaved 2 of 5 Code**
  - **UPC/EAN/JAN Codes**
- **AUTOMATIC CODE RECOGNITION**
- **FULL DUPLEX SERIAL OR PARALLEL ASCII OUTPUT**
- **EXTENSIVE CONFIGURATION CONTROL THROUGH SOFTWARE COMMANDS**
- **DECODER IC IN A STANDARD 40 PIN DIP PACKAGE**
- **AUDIO AND VISUAL FEEDBACK CONTROL**
- **SINGLE 5 VOLT SUPPLY**



Description

Hewlett-Packard's HBCR-1800 Bar Code Decoder IC is a high performance product designed to simplify the implementation of bar code reading capability in any OEM system. The standard 40 pin decoder IC has been specially designed to work with any of Hewlett-Packard's digital wands. When combined with an external RAM chip, the result is a component-level reader that allows a manufacturer to easily add bar code reading to his equipment.

The standard decoding chip supports four of the most popular codes: 3 of 9 Code, Extended 3 of 9 Code, Interleaved 2 of 5 Code, and UPC/EAN/JAN Codes. If more than one standard code is enabled, the reader will automatically recognize and decode the code being scanned. Bi-directional scanning is allowed for all codes except UPC/EAN/JAN with supplemental digits. For 3 of 9 Codes and Interleaved 2 of 5 Code, a maximum of 32 characters (not including start and stop characters) are allowed.

The decoder IC may be set to communicate in either serial or parallel ASCII. Operator feedback is supported through pins that allow for external LED drive and a beeper drive circuits. In addition, there are thirteen programmable functions covering items from terminator character selection to the tone of the beeper.

Applications

Bar codes are rapidly becoming a preferred alternative to other forms of data entry. Bar coding has proven faster and more accurate than keyboard entry. In addition, bar code scanning typically has a higher first read rate and greater data accuracy than Optical Character Recognition. When compared to magnetic stripe encoding, bar code offers significant advantages in flexibility of media, symbol placement and immunity to electromagnetic fields.

Manufacturers of data collection terminals, point-of-sale terminals, keyboards, weighing scales, and other data collection and material handling equipment are finding a growing demand for bar code reading capability in their products. The HBCR-1800 Bar Code Decoder IC makes it easy to add this capability without the need to invest in the development of bar code decoding software.

HBCR-1800 Bar Code Decoder IC makes it easy to add this capability without the need to invest in the development of bar code decoding software.

The 40 pin decoder IC may be easily configured with most common microprocessors using either a parallel ASCII or serial ASCII interface. The IC may be added to an existing board, designed into an add-on board, or designed into an entirely new system. Using the decoder IC as an integral part of the host system will eliminate the need for the external bar code readers which are often used to perform the same function.

Decoder IC Specifications

General Information

The HBCR-1800 Bar Code Decoder IC consists of an NMOS decoding IC in a 40 pin Dual In-Line package. The readers require an external 1K x 8 bit multiplexed RAM chip (Intel 8185 or similar) or a 1K x 8 bit RAM and an address latch chip (Mostek MK4801 or similar and a 74LS373). To complete the reader, a 12 MHz crystal must also be added.

The decoding IC is designed to interface with most standard microprocessors, and can communicate in either serial or parallel ASCII. It provides complete compatibility with the output from Hewlett-Packard digital bar code wands.

Performance Features

Bar Codes Supported

The HBCR-1800 Bar Code Decoder IC is capable of reading four popular bar code symbologies: 3 of 9 Code, Extended 3 of 9 Code, Interleaved 2 of 5 Code and UPC/EAN/JAN Codes.

The 3 of 9 Code, an alphanumeric code, and the Extended 3 of 9 Code, a full 128 character ASCII version of the 3 of 9 Code, may be read bi-directionally for message lengths up to a maximum of 32 characters. An optional checksum character may be used with these codes, and the decoder IC may be configured to verify this character prior to data transmission. Enabling the Extended 3 of 9 Code will disable the standard 3 of 9 Code as the two are mutually exclusive.

The Interleaved 2 of 5 Code, a compact numeric only bar code, may also be read bi-directionally for message lengths up to a maximum of 32 characters. To enhance data accuracy, an optional checksum character verification and/or label length checking may be enabled.

All popular versions of the UPC, EAN, and JAN bar codes may be read bi-directionally, including UPC-A, UPC-E, EAN-8, EAN-13, JAN-8, and JAN-13. All codes may be enabled simultaneously or only the UPC codes may be enabled.

UPC, EAN and JAN codes with complementary two digit or five digit supplemental encodations, or "add-ons", may also be read in one of two ways. If UPC, EAN and JAN codes are enabled but neither two digit nor five digit supplemental encodations are enabled, then only the main part of the symbols printed with supplemental encodations will be read. If the two digit or the five digit supplemental encodations are enabled, then only symbols with these supplementals will be read. In this case, the symbols may only be read in the direction which results in the supplement being scanned last.

Automatic code recognition is provided for the Interleaved 2 of 5 Code, UPC/EAN/JAN Codes, and either the 3 of 9 Code or the Extended 3 of 9 Code. The decoder IC's default setting is for simultaneous reading of the 3 of 9 Code, Interleaved 2 of 5 Code and UPC/EAN/JAN Codes.

Wand Input

The decoder IC has been specially designed to operate with any of several Hewlett-Packard digital bar code wands.

Wand input can be disabled by the host system through a software command. This allows the application program to control the operator's ability to enter bar code data, thereby preventing inadvertant data entry and allowing the host to verify each scan before enabling subsequent scans.

The wand is connected to pin 12 of the decoder IC (see Figures 1 and 2).

Data Communications

The decoder IC can communicate with the host system through either a serial ASCII or parallel ASCII port. The parallel port allows for faster data communication between the two devices. Both parallel and serial ports are bi-directional.

The serial port may also be connected directly to RS-232-C level shifters to produce an RS-232-C compatible output. A wide range of baud rate, parity, stop bits and terminator characters may be selected, as described in Table 1. In addition, XON/XOFF pacing for the decoder IC's data transmission is available.

The parallel port utilizes both a send and receive handshake for data transfer between the decoder IC and the host system. Timing diagrams for these handshakes are shown on page 5.

The decoder IC has a 255 character output buffer which will store data if transmission to the host is prevented. A buffer overflow will actuate a signal on the beeper line for the beeper to sound three times in rapid succession.

Feedback Features

The decoder IC has several provisions for signalling operator feedback. Pin 14 provides a signal for an LED driver and pin 15 provides a signal for a beeper driver. An LED or beeper driver connected to the decoder IC may be controlled directly by the IC, with a signal generated after a good read; or may be controlled by the host system. In addition, the tone of the beeper can be varied by a software command to be one of 16 different tones.

Power Requirements

Both the decoder IC and the wands operate from a single +5 V DC power supply. The maximum current draw for the decoder IC is 175 mA. The maximum ripple voltage should be less than 100 mV peak-to-peak.

Configuration Control

Configuration of the decoder IC may be determined through hardwire connections and/or through software commands. Hardwire selection is limited to key operating parameters. A much greater range of configuration control is available through software commands. A summary of the decoder IC features and configuration control these features is presented in the following table.

Table 1. Summary of Features and Configuration Control

Feature	Function of Value	Hardwire/ Software Control[1]	Default Setting[2]	Mode[3]	Notes
Mode of Operation	Parallel or Serial Mode	Hardwire	Parallel	N/A	
Baud Rate	300, 1200, 2400, 9600	Hardwire	300 Baud	Serial	
Parity	0's, 1's, Odd, Even	Hardwire	0's	Serial	4
Stop Bits	1 or 2	Hardwire	2	Serial	
Terminator Character	CR, CR/LF, HT, None	Hardwire	CR	Serial	
	User Defined (10 Characters Max.)	Software	CR	Both	5
Header Character	User Defined (10 Characters Max.)	Software	No Header Character	Both	
Data Output Pacing	XON/XOFF	Software	No Pacing	Both	
Industrial Code Select	3 of 9 Code Interleaved 2 of 5 Code	Software	3 of 9 Code Interleaved 2 of 5 Code	Both	
	Extended 3 of 9 Code	Both			
UPC/EAN/JAN Code Select	UPC/EAN/JAN together; or UPC Only	Software	UPC/EAN/JAN Codes		
	Enable 2 or 5 Digit Supplements	Software	Supplements Not Enabled		
	Suppress Zeros UPC-E	Software	Zeros Included		
Checksum Verification Enable	3 of 9 Code Checksum	Both	No Checksum Verification	Both	
	Interleaved 2 of 5 Checksum	Software			
Interleaved 2 of 5 Label Length Check	User Defined up to 32 Characters or Variable Length	Software	Variable Length	Both	
Scanner Disable	Disables Wand Input	Software	Wand Input Enabled	Both	
Good Read Beep Select	Enables Good Read Beep in one of 16 Tones	Software	Beep Signal Enabled; Tone = 15	Both	
Sound Tone	External Command to Sound Tones Defines 1 of 16 Tones	Software	N/A	Both	
LED Control	Controls LED Driver Circuit	Software	LED to Flash Upon Good Read	Both	
Status Request	Gives Status of Decoder IC Configuration	Software	N/A	Both	
Hard Reset	Resets Decoder IC to Hardwire Configuration and Default Software Settings	Software	N/A	Both	

Notes:

1. Software commands are sent by means of escape sequence.
2. Default settings are those settings which result when the relevant pins have been tied to +5V and no software commands have been sent to the decoder IC.
3. Some functions apply only when the decoder IC is operating in the serial mode. Others apply in both the parallel and serial modes.
4. In the parallel mode, the parity is always odd.
5. In the parallel mode the terminator character is "CR" unless changed through software commands.

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Voltage	V_{CC}	4.5		5.5	V	7
Ambient Temperature	T_A	0		70	°C	
Crystal Frequency	XTAL		12		MHz	8

Note:
7. Maximum power supply ripple of 100 mV peak-to-peak.
8. 12 MHz crystal is recommended.

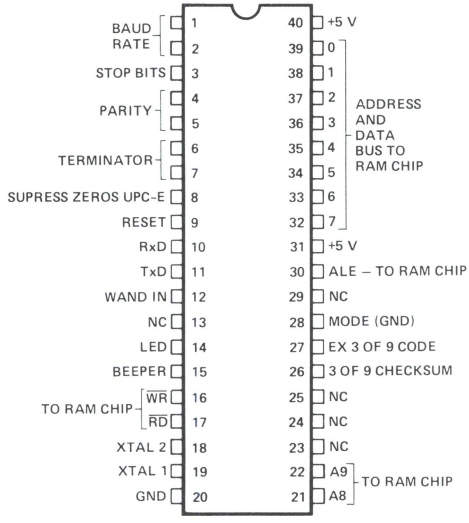
Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	−65	+150	°C	
Pin Voltage	V_{IN}	−0.5	+7.0	V	9
Power Dissipation	P_D		2.0	Watts	

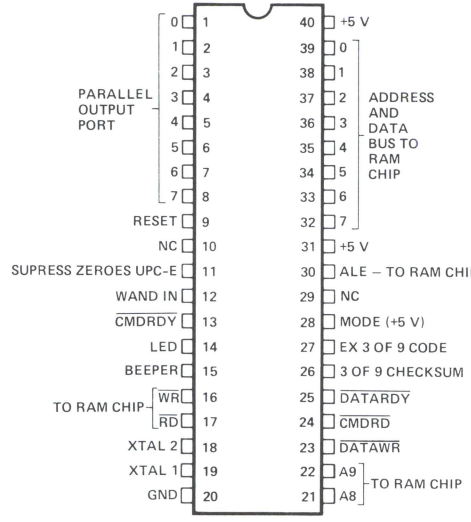
Note:
9. Voltage on any pin with respect to ground.

Block Diagrams

SERIAL PINOUT



PARALLEL PINOUT



NC — Pins should be left floating

Figure 1.

Figure 2.

DECODER IC TO MEMORY

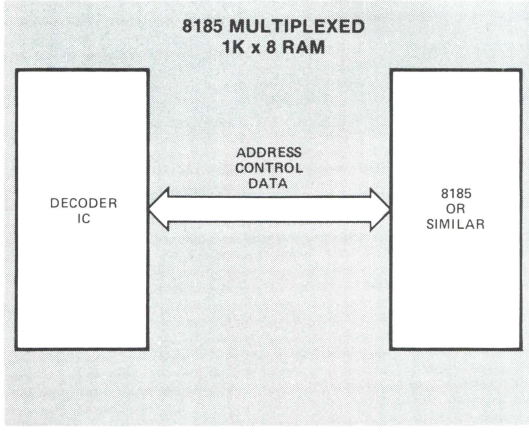


Figure 3.

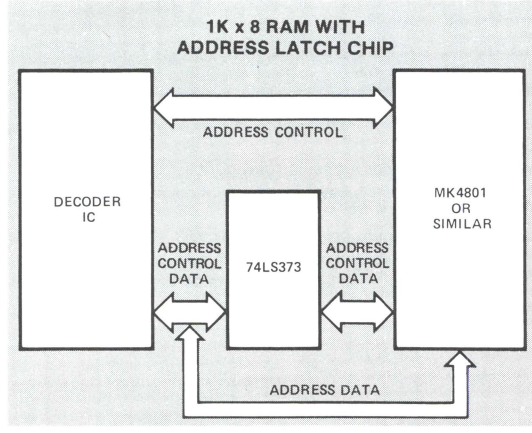
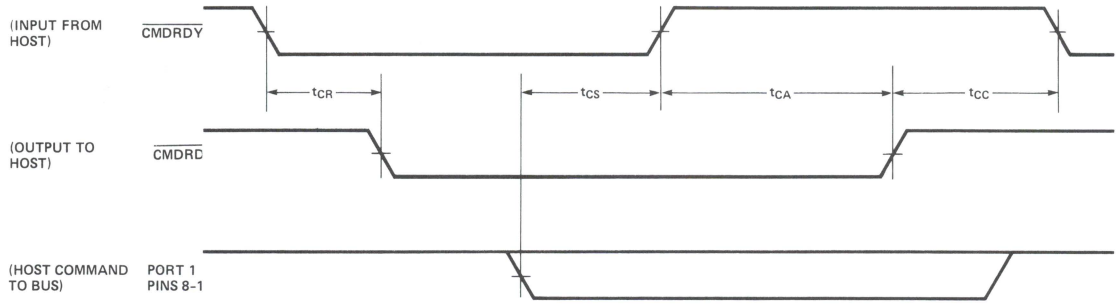


Figure 4.

Parallel Mode Handshake Timing

HOST COMMANDS RECEIVED BY DECODER IC



*t_{CR} = Falling edge of COMMAND READY to falling edge of COMMAND READ. Max. = 22 μs (MICRO SECONDS).

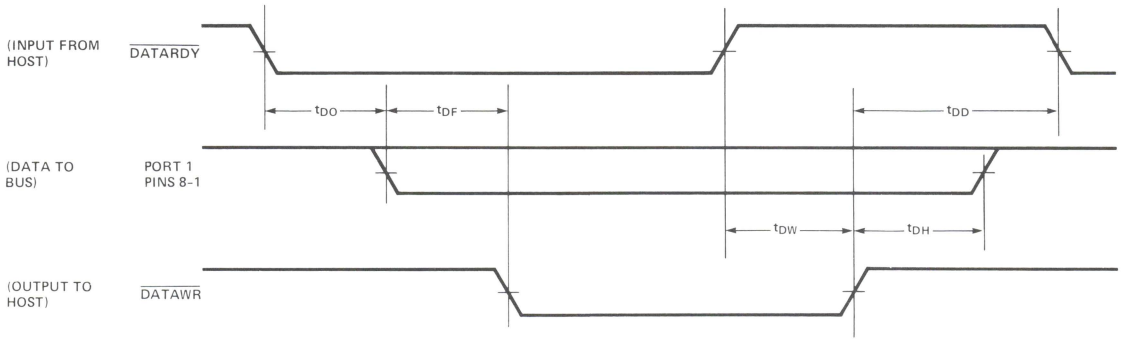
t_{CS} = Command setup to rising edge of COMMAND READY. Min. = 0 μs.

*t_{CA} = Rising edge of COMMAND READY to rising edge of COMMAND READ. Typical = 6 μs.

t_{CC} = Rising edge of COMMAND READ to falling edge of COMMAND READY. Min. = 0 μs.

***Note:** These timing specifications given are based on the assumptions that the wand is not active at the time. Since the wand input to the microprocessor is interrupt driven, the timing might be stretched if the wand is active during that time. All the timings assume the microprocessor runs at 12 MHz.

DECODER IC DATA SENT TO HOST



*t_{DO} = Falling edge of DATA READY to data output to bus. Max. = 140μs.

This number reflects that there is no decoding in progress, no status, terminal ID, header or terminator change command is being executed at the time.

*t_{DF} = Data output to bus to falling edge of DATA WRITE. Max. = 2 μs

*t_{DW} = Rising edge of DATA READY to rising edge of DATA WRITE. Max. = 5 μs.

*t_{DH} = Data hold after rising edge of DATA WRITE. Max. = 2 μs.

t_{DD} = Rising edge of DATA WRITE to falling edge of DATA READY. Min. = 0 μs.

DC Characteristics (T_A = 0° C to 70° C, V_{CC} = 4.5V to 5.5V, V_{SS} = 0V)

Symbol	Parameter	Min.	Max.	Unit	Test Conditions
V_{IL}	Input Low Voltage	−0.5	0.8	V	
V_{IH}	Input High Voltage (except Pins 9 and 18)	2.0	V_{CC} + 0.5	V	
V_{IH1}	Input High Voltage (Pins 9 and 18)	2.5	V_{CC} + 0.5	V	Pin 19 to V_{SS}
V_{OL}	Output Low Voltage (Pins 1-8, 10-17, 21-28)		0.45	V	I_{OL} = 1.6 mA
V_{OL1}	Output Low Voltage (Pins 30 and 32-39)		0.45	V	I_{OL} = 3.2 mA
V_{OH}	Output High Voltage (Pins 1-8, 10-17 and 21-28)	2.4		V	I_{OH} = −80 μA
V_{OH1}	Output High Voltage (Pins 30 and 32-39)	2.4		V	I_{OH} = −400 μA
I_{IL}	Input Low Current (Pins 1-8, 10-17 and 21-28)		−800	μA	V_{IN} = 0.45V
I_{IL2}	Input Low Current (Pin 18)		−2.5	mA	Pin 19 to V_{SS}; V_{IN} = 0.45V
I_{LI}	Input Leakage Current (Pins 32-39)		±10	μA	0.45 < V_{IN} < V_{CC}
I_{IH1}	Input High Current to Pin 9 for Reset		500	μA	V_{IN} = V_{CC} −1.5
I_{CC}	Power Supply Current		175	mA	All Outputs Disconnected

Wand I/O Interfaces

Note:
The shield must be connected to ground for proper wand operation.

Figure 5. Wand Interfaces

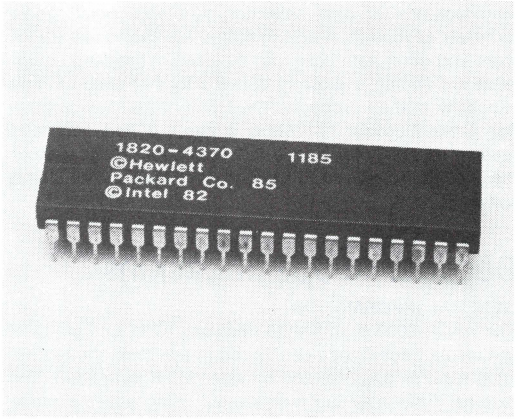
HEWLETT PACKARD

MULTI-PURPOSE BAR CODE DECODER IC

HBCR-2000

Features

- **IDEAL FOR HAND SCANNING APPLICATIONS AND MANY AUTOMATED SCANNING APPLICATIONS**
- **COMPATIBLE WITH THE SCANNERS NEEDED FOR VIRTUALLY ALL HAND-HELD SCANNING APPLICATIONS**
  - **— Laser Scanners**
  - **— Wands**
  - **— Slot Readers**
- **WIDE SELECTION OF INDUSTRY STANDARD BAR CODES SUPPORTED**
  - **— Code 39 (3 of 9 Code)**
  - **— Extended Code 39**
  - **— Interleaved 2 of 5 Code**
  - **— UPC/EAN/JAN Codes**
  - **— Codabar (NW7 Code)**
  - **— Code 128**
- **AUTOMATIC CODE RECOGNITION**
- **FULL DUPLEX SERIAL ASCII INTERFACE**
- **EXTENSIVE CONFIGURATION CONTROL THROUGH SOFTWARE COMMANDS**
- **STANDARD 40 PIN DIP PACKAGE**
- **AUDIO AND VISUAL FEEDBACK CONTROL**
- **SINGLE 5 VOLT SUPPLY**



Description

Hewlett-Packard's HBCR-2000 Multipurpose Bar Code Decoder IC offers a flexible bar code decoding capability designed to give OEMs the ability to address a large number of industry segments and applications. The decoder IC's flexibility is made possible through sophisticated software which allows the IC to accept data input from a wide variety of digital scanners and to decode the most popular bar code symbologies with full automatic code recognition. Implementation of the decoder IC is easy since it requires only a few supporting chips and provides a standard interface to the host.

The HBCR-2000 is compatible with the scanners needed for virtually all hand scanning applications. Specifically, it is compatible with moving-beam laser scanners such as the Symbol Technologies' LS7000, Symbol Technologies' LS7000 II, and Spectra Physics' SP2001; fixed-beam non-contact scanners; Hewlett-Packard digital wands; and Hewlett-Packard digital slot readers.

The decoder IC is also an excellent decoding solution for a number of the stationary scanning applications found in automated systems. In this case, the scan rates for moving-beam applications must be similar to the scan rates for most hand-held laser scanners (35-45 scans/second) and the scan speeds for fixed-beam applications must be similar to the scan speeds for wands and slot readers. For moving beam applications, it is also important for the scanner to utilize the three laser control lines on the IC.

The standard decoder IC supports the bar code symbologies now being used for most applications in the industrial, retail, commercial, government, and medical markets. The bar codes supported are: Code 39 (3 of 9 Code), Extended Code 39, Interleaved 2 of 5 Code, UPC/EAN/JAN Codes, Codabar (NW7 Code) and Code 128. If more than one code is enabled, the decoder IC will automatically recognize and decode the code being scanned. Bi-directional scanning is allowed for all codes except UPC/EAN/JAN codes with supplemental digits.

The HBCR-2000 communicates with the host through a flexible, full duplex serial ASCII interface. OEMs may choose either to convert this interface to a standard data communications protocol such as RS-232-C/V.24 or to connect the decoder IC directly to another microprocessor for data processing or data re-formatting. Operator feedback is supported through pins that allow for external LED drive and beeper drive circuits. In addition, there are 21 programmable functions covering items from laser redundancy check to the tone of the beeper.

Applications

Bar codes are rapidly becoming a preferred alternative to other forms of data entry. Bar coding has proven faster and more accurate than keyboard data entry. In addition, bar code scanning typically has a higher first read rate and greater data accuracy than optical character recognition. When compared to magnetic stripe encoding, bar code offers significant advantages in flexibility of media, symbol placement and immunity to electromagnetic fields.

Manufacturers of data collection terminals, point-of-sale terminals, keyboards, weighing scales, automated test equipment and other data collection or material handling equipment are finding a growing demand for bar code reading capability in their products. The HBCR-2000 Multipurpose Bar Code Decoder IC makes it easy to add bar code reading capability for a wide variety of applications without the need to invest in the development of bar code decoding software.

Decoder IC Specifications

GENERAL INFORMATION

The HBCR-2000 is an NMOS decoding IC in a 40 pin Dual In-Line package. When configured in a system, the HBCR-2000 requires a crystal and an external 1K byte RAM. The external RAM may be implemented using either a multiplexed RAM chip (Intel 8185 or equivalent) or a non-multiplexed RAM chip and a latch chip (Mostek MK4801 or equivalent and 74LS373). The recommended crystal frequency is 11.059 MHz (CTS Knights R1032-6BA.11.059 or equivalent).

The decoder IC is designed to interface with most standard microprocessors or other host systems through a full duplex serial asynchronous ASCII port. It offers complete compatibility with Hewlett-Packard digital wands and digital slot readers as well as hand-held laser scanners from both Spectra Physics, Inc. and Symbol Technologies, Inc. Other scanners, such as hand-held fixed-beam non-contact scanners and the scanners used in some stationary scanning applications, may also be used with the IC.

Performance Features

BAR CODES SUPPORTED

The HBCR-2000 decoder IC is capable of reading six popular bar code symbologies: Code 39 (3 of 9 Code), Extended Code 39, Interleaved 2 of 5 Code, UPC/EAN/JAN Codes, Codabar (NW7 Code), and Code 128.

Code 39, an alphanumeric code, and Extended Code 39, a full 128 character ASCII version of Code 39, may be read bi-directionally for message lengths up to a maximum of 32 characters. An optional check character may be used with these codes, and the decoder IC may be configured to verify this character prior to data transmission. Enabling Extended Code 39 will disable standard Code 39 as the two are mutually exclusive.

The Interleaved 2 of 5 Code, a compact numeric only bar code, may also be read bi-directionally for message lengths from 4 to 32 characters. To enhance data accuracy, optional check character verification and/or label length checking may be enabled.

All popular versions of the UPC, EAN, and JAN bar codes may be read bi-directionally, including UPC-A, UPC-E, EAN-8, EAN-13, JAN-8, and JAN-13. All codes may be enabled simultaneously or only the UPC codes may be enabled. UPC, EAN, and JAN symbols with complementary two digit or five digit supplemental encodations, or "add-ons", may also be read.

Codabar, a numeric only bar code with special characters, may be read bi-directionally for message lengths up to a maximum of 32 characters. The start and stop characters in the symbol are normally transmitted, but transmission of these characters may be disabled through a software command.

Code 128, a compact full ASCII bar code, may also be scanned bi-directionally for message lengths up to a maximum of 32 characters.

Automatic code recognition is provided for the Interleaved 2 of 5 Code, UPC/EAN/JAN Codes, Codabar, Code 128, and either Code 39 or Extended Code 39. Any subset of these codes may be selected for decoding. The decoder IC's default setting is for simultaneous reading of Code 39, Interleaved 2 of 5 Code with variable lengths, UPC/EAN/JAN Codes without supplements, Codabar, and Code 128.

SCANNER INPUT

The HBCR-2000 is designed to accept a digital input signal either from a fixed-beam scanner, such as a wand, slot reader, or fixed-beam non-contact scanner, or from a moving-beam scanner such as a hand-held laser scanner. The state of pin 7 must be set prior to power-up to reflect the type of scanner connected to the decoder IC.

The decoding software has been specially designed to operate with any of Hewlett-Packard's digital bar code wands. Sapphire-tip digital wands feature a scan angle of 0 to 45 degrees, a variety of resolutions, and a TTL compatible digital output. A complete wand selection guide is presented in Table 2.

The decoder IC is also designed specifically for operation with Hewlett-Packard's digital slot readers. These slot readers feature a sealed case with a slot width of 3.2 mm (0.125 in.) and either an infrared (880 mm) or visible red (660 mm) LED light source. A separate module which contains the slot reader optics and electronics is available for stationary scanning applications or for configuration in applications requiring a different slot width.

The decoding software for moving-beam scanners has been designed to work with hand-held laser scanners manufactured by Spectra Physics, Inc. and Symbol Technologies, Inc. The delay time for automatic laser shutoff is adjustable through a software command to the IC. A redundancy check feature is available for applications which require extreme accuracy. Applications which require and ability to sense motor failure in a laser scanner or to calculate the ratio of laser on-time to laser off-time must support these requirements through external hardware.

The digital input signal from the scanner is connected to pin 12. When the decoder IC is used with a hand-held laser scanner, the laser enable, laser trigger, and scanner synchronization signal lines are connected to pins 6, 8, and 13, respectively. Scanner input can be disabled by the host system though a software command. This allows the application program to enable bar code data entry only when

expecting the operator to enter data which has been encoded in bar code. The decoder IC also offers a single read mode which can be enabled through a software command. The single read mode allows the application program to prevent bar code data entry until a "Next Read" command is sent, thereby allowing the host to process transmissions and verify each scan before enabling subsequent decodes.

DATA COMMUNICATIONS

The decoder IC communicates with the host system through a full-duplex, asynchronous, serial ASCII port. A wide range of baud rate, parity, stop bits, and terminator characters may be selected, as described in Table 1. In addition, both request-to-send/clear-to-send hardware handshake and X_{ON}/X_{OFF} (DC1/DC3) character pacing are available for control of the decoder IC's data transmission.

OPERATOR FEEDBACK

The decoder IC has several provisions for signalling operator feedback. Pin 14 provides a signal for an LED driver and pin 15 provides a signal for a beeper driver. An LED or beeper driver connected to the decoder IC may either be controlled directly by the IC, with a signal generated after a good read, or may be controlled by the host system. In addition, the tone of the beeper can be varied by a software command to be one of 16 tones or the beeper may be silenced.

POWER REQUIREMENTS

The decoder IC operates from a single 5 V DC power supply. The maximum current draw is 175 mA. The maximum ripple voltage for the power supply should be less than 100 mV peak-to-peak.

CONFIGURATION CONTROL

Configuration of the decoder IC may be determined through hardwire connections and/or through software commands. Hardwire selection is limited to key operating parameters. A much greater range of configuration control is available through software commands. A summary of the decoder IC features and the configuration control available for these features is presented in Table 1. A users manual which provides detailed configuration information and example schematics is supplied with the HBCR-2000.

Handling Precautions

The decoder IC is extremely sensitive to electrostatic discharge (ESD). It is important that good anti-static procedures be observed when handling the IC. The package should not be opened except in a static free environment.

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Voltage	V_{CC}	4.5		5.5	V	1
Ambient Temperature	T_A	0		70	°C	
Crystal Frequency	XTAL		11.059		MHz	2
Element Time Interval (Moving-Beam)	ETI_M	22		555	μsec	2, 3, 4, 5
Element Time Interval (Fixed-Beam)	ETI_F	150		70,000	μsec	2, 3, 5, 6, 7

NOTES:

1. Maximum power supply ripple of 100 mV peak-to-peak.
2. Crystal frequencies from 3.5 MHz to 12 MHz may be used. For frequencies other than 11.059 MHz, multiply the specified baud rates and beeper frequencies by $\frac{XTAL}{11.059\ MHz}$ and multiply the element time interval ranges by $\frac{11.059\ MHz}{XTAL}$. The ETI ranges specified a crystal frequency of 11.059 MHz.
3. An element time interval (ETI) is the time period in the digital signal from the scanner that corresponds to the physical width of a printed element (bar or space) in the bar code symbol ETI_M applies when pin 7 is tied low and ETI_F applies when pin 7 is tied high.
4. Corresponds to a scan rate of 35 to 45 scans per second, a scan rate which is common for hand-held laser scanners.
5. Element time intervals which are smaller than the minimum ETI's specified will still be processed, but with additional width errors that may cause the input signal to be undecodable.
6. The maximum scan speed may be calculated by dividing the smallest narrow element width by 150 μsec. For example, for 0.19 mm (0.0075 in.) narrow elements, the maximum scan speed is 127 cm/sec (50 in./sec).
7. The minimum scan speed may be calculated by dividing the largest wide element width by 70,000 μsec. For example, for 1.52 mm (0.060 in.) wide elements, the minimum scan speed is 2.2 cm/sec (0.9 in./sec).

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	−65	+150	°C	
Pin Voltage	V_{IN}	−0.5	+7.0	V	8
Power Dissipation	P_D		1.5	Watts	

Note:

8. Voltage on any pin with respect to ground.

TABLE 1. SUMMARY OF FEATURES AND CONFIGURATION CONTROL

	Feature	Function or Value	Hardwire/ Software Control[9]	Default Setting[10]
Scanner Selection/Control	Scanner Type	Wand/Slot Reader or Moving Beam Laser Scanner	Hardwire	Moving Beam Laser Scanner
	Laser Shutoff Delay	Defines Laser On-Time prior to Automatic Shutoff from 0 to 10 seconds in 100 ms steps	Software	3 seconds
	Laser Redundancy Check	Enables Requirement for Two Consecutive, Identical Decodes for a Good Read	Software	Not Enabled
	Scanner Input Enable	Enables Data Acquisition from Scanner	Software	Enabled
	Single Read Mode	Enables Requirement for a 'Next Read' Command before Processing the next Scanner Input Signal	Software	Not Enabled
Code Selection	Code Select	Extended Code 39	Both	Code 39 Interleaved 2 of 5 Code UPC/EAN/JAN Codes Codabar Code 128
		Code 39 Interleaved 2 of 5 Code UPC/EAN/JAN Codes Codabar Code 128	Software	
	UPC/EAN/JAN Decoding Options	UPC/EAN/JAN together; or UPC Only	Software	UPC/EAN/JAN together
		Enable 2 or 5 Digit Supplements	Software	Supplements Not Enabled
	Check Character Verification Enable	Code 39 Check Character	Both	No Check Character Verification
		Interleaved 2 of 5 Code Check Character	Software	
	Codabar Data Transmission Option	Transmit or Suppress Start/Stop Characters	Software	Transmit
	Interleaved 2 of 5 Label Length Check	User Defined from 4 to 32 Characters or Variable Length	Software	Variable Length
Data Communications	Baud Rate	1200, 2400, 4800, 9600	Hardwire	1200
	Parity	0's, 1's, Odd, Even	Hardwire	0's
	Stop Bits	1 or 2	Hardwire	1
	Terminator Character	CR, CR/LF, ETX, None	Hardwire	CR
		User Defined (10 Characters Max.)	Software	
	Header Character	User Defined (10 Characters Max.)	Software	No Header Character
	Data Output Pacing	RTS/CTS	Hardwire	No Pacing
		X_{ON}/X_{OFF}	Software	
Operator Feedback	Good Read Beep Select	Enables Good Read Beep and sets 1 of 16 tones	Software	Beep Enabled; Tone 12
	Sound Tone	External Command to Initiate Beep Signal in 1 of 16 tones	Software	N/A
	LED Control	Defines LED Control to be Internal, External, or both	Software	LED to Flash Automatically Upon Good Read
System Control	Status Request	Gives Status of Decoder IC Configuration	Software	N/A
	Hard Reset	Resets Decoder IC to Hardwire Configuration and Default Software Settings	Software	N/A

NOTES:

9. Hardwire control is accomplished by tying the appropriate input pins high or low. Software commands are sent by means of escape sequences.
10. Default settings are those settings which result when the relevant input pins have been tied to Ground and no software commands have been sent to the decoder IC.

Pinout

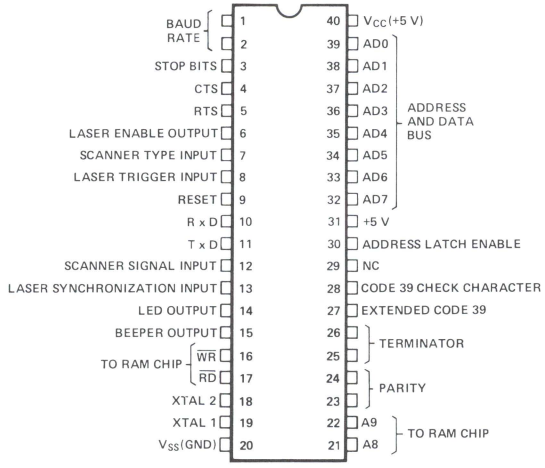


Figure 1.

Block Diagrams

DECODER IC TO MEMORY

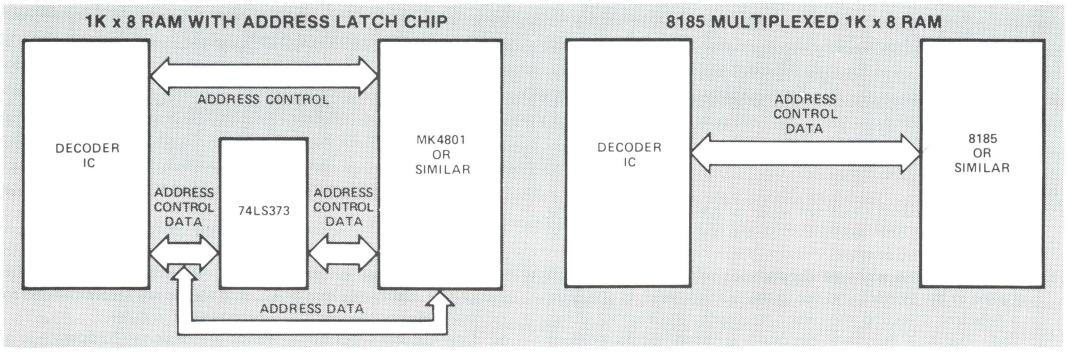


Figure 2.

Figure 3.

Scanner Compatibility

The HBCR-2000 is compatible with the complete line of Hewlett-Packard digital wands, Hewlett-Packard digital slot readers, and hand-held laser scanners manufactured by both Symbol Technologies, Inc. and Spectra Physics, Inc.

The selection of Hewlett-Packard digital wands available for use with the HBCR-2000 is presented in Table 2. For the two families of sapphire-tip digital wands, the most widely used wands are those which specify a recommended nominal narrow element width of 0.19 mm (0.0075 in.). These wands are capable of reading bar codes printed with a variety of different printers and over a wide range of printed resolutions (as specified by narrow element widths) and are, therefore, considered to be general-purpose wands. The higher resolution wands, with a recommended nominal narrow element of 0.13 mm (0.005 in.), are recommended for applications in which only high resolution bar codes are being read. For applications which require a scanner to read medium or low resolution bar codes, particularly those with edge roughness, ink smearing, spots and voids, or other minor print flaws, the wands which specify a recommended nominal narrow element width of 0.3 mm (0.012 in.) or 0.33 mm (0.013 in.) are recommended.

The Hewlett-Packard slot readers and slot reader modules which are available for use with the HBCR-2000 are presented in Table 3. The standard slot readers have a slot width of 3.2 mm (0.125 in.) and are, therefore, capable of reading bar codes on anything from paper to double-laminated badges. For applications which require a different slot width or which require a fixed-beam scanner in an automated system, a module which contains the slot reader optics and electronics assembly is also available.

The hand-held laser scanners compatible with the HBCR-2000 include the Symbol Technologies' LS7000, Symbol Technologies' LS7000 II, and Spectra Physics' SP2001. For detailed information on these scanners, please contact these companies directly.

TABLE 2. HEWLETT-PACKARD DIGITAL BAR CODE WANDS

	Part Number	Recommended[11, 12] Nominal Narrow Element Width	Emitter[13] Wavelength	Tilt Angle	Typical Current	Case Material	Switch	Tip
Low Cost	HEDS-3000	0.3 mm (0.012 in.)	700 nm	0-30°	42 ma	ABS Plastic	Yes	Open
	HEDS-3050	"	"	"	"	"	No	"
Sapphire-Tip	HBCS-2200	0.19 mm (0.0075 in.)	700 nm	0-45°	42 ma	Polycarbonate	Yes	Sapphire Ball
	HBCS-2300	"	"	"	"	"	No	"
	HBCS-2400	0.13 mm (0.005 in.)	820 mm	"	"	Polycarbonate	Yes	"
	HBCS-2500	"	"	"	"	"	No	"
Low Current Sapphire-Tip[14]	HBCS-5000	0.33 mm (0.013 in.)	655 nm	0-45°	3.5 ma	Polycarbonate	Yes	Sapphire Ball
	HBCS-5100	"	"	"	"	"	No	"
	HBCS-6100	"	"	"	"	Metal	"	"
	HBCS-5200	0.19 mm (0.0075 in.)	"	"	"	Polycarbonate	Yes	"
	HBCS-5300	"	"	"	"	"	No	"
	HBCS-6300	"	"	"	"	Metal	"	"
	HBCS-5400	0.13 mm (0.005 in.)	820 mm	"	"	Polycarbonate	Yes	"
	HBCS-5500	"	"	"	"	"	No	"
	HBCS-6500	"	"	"	"	Metal	"	"

NOTES:

11. The nominal narrow element width of a symbol may also be referred to as the resolution of the symbol or as the 'x' dimension of the symbol.
12. Nominal narrow element (bar/space) width, a term which applies to the symbol and not to the scanner itself, is specified to facilitate selecting the best scanner for the symbol being read. The scanners are designed to accomodate printing tolerances around the nominal dimension specified. Bar codes having larger nominal narrow element widths (ie. lower resolution) than specified may also be read as long as print quality is good.
13. Wands with an emitter wavelength of 655 mm are recommended for reading bar codes printed on regular (white) thermal paper or printed with Hewlett-Packard's Thinkjet printer. Either 655 mm or 700 mm wands are recommended for bar codes printed with dye-based ink or in color.
14. Low current sapphire-tip wands are designed to operate in all ambient light environments including in direct sunlight and under high intensity lamps.

TABLE 3. HEWLETT-PACKARD DIGITAL SLOT READERS

Part Number	Configuration	Recommended[15] Nominal Narrow Element Width	Emitter[16] Wavelength	Temperature Range	Case Material
HBCS-7000	Complete Slot Reader	0.19 mm (0.0075 in.)	660 nm	-20 to +55° C	Metal
HBCS-7001	Slot Reader Module	"	660 nm	"	"
HBCS-7100	Complete Slot Reader	0.19 mm (0.0075 in.)	880 nm	-40 to +70° C	"
HBCS-7101	Slot Reader	"	880 nm	"	"

NOTES:

15. The aperture design of the slot reader optical system allows reading both high resolution bar code symbols and poorly printed medium or low resolution bar code symbols with the same scanner.
16. The 880 nm slot reader is recommended for bar code symbols printed with carbon-based inks or for "black-on-black" bar code symbols. The 660 nm slot reader is recommended for bar code symbols printed with dye-based inks or printed on regular thermal paper.

HEWLETT PACKARD

CMOS MULTI-PURPOSE BAR CODE DECODER IC

HBCR-2010

Description

The HBCR-2010 is a CMOS (low power) version of the HBCR-2000. With the exception of the power consumption, the performance of the HBCR-2010 is identical to the HBCR-2000. Please refer to the HBCR-2000 data sheet and manual (part # 5954-2165) for a complete discussion of the capabilities of the product. The following information summarizes the differences between the HBCR-2000 and the HBCR-2010.

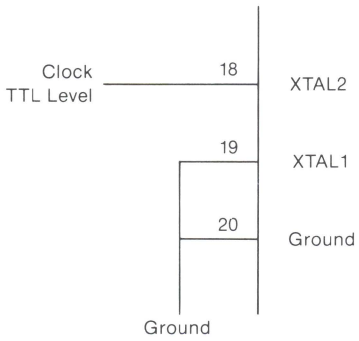
Power Consumption (at V_{CC} of 5.0 Volts)

Decoder IC	Typical	Maximum	Idle Mode Typical
HBCR-2000	—	175 mA	N/A
HBCR-2010	15 mA	19 mA	4 mA

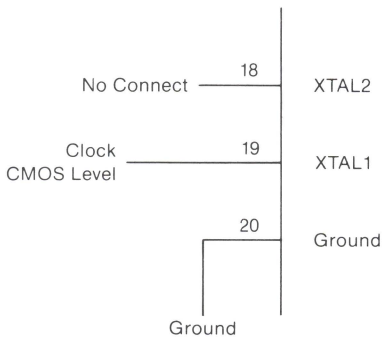
Note:
Idle mode only occurs when the HBCR-2010 decoder is in the Wand Mode. Idle mode does not occur when the HBCR-2010 decoder is in the Laser Mode.

External Clock Drivers

If an external clock is to be used, the function of XTAL1 (pin 19) and XTAL2 (pin 18) is different for the HBCR-2010.



HBCR-2000



HBCR-2010

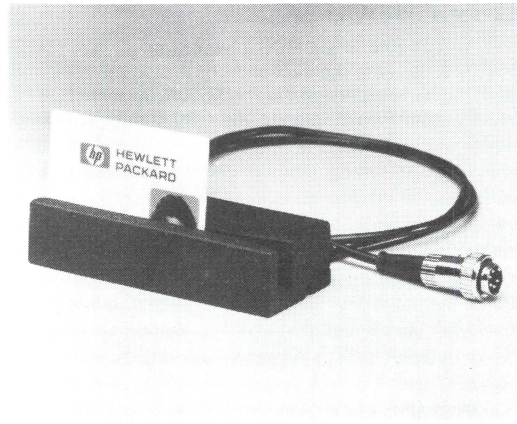
HEWLETT PACKARD

INDUSTRIAL DIGITAL BAR CODE SLOT READERS

HBCS-7000
HBCS-7050
HBCS-7100
HBCS-7150

Features

- **MULTI-RESOLUTION**
  - **— Compatible with Virtually All Bar Code Resolutions**
- **LARGE SLOT WIDTH**
  - **— Allows Reading Multiple Laminated Cards**
- **SEALED METAL CASE (IP 66/67)**
  - **— Can Be Installed Outdoors or in Wet Environments**
- **TAMPER PROOF DESIGN**
  - **— Ideal for Security Applications**
- **MINIMAL FIRST BAR DISTORTION**
  - **— Compatible with Most Decoding Software**
- **AVAILABLE IN EITHER VISIBLE 660 nm OR INFRARED 880 nm VERSIONS**
- **WIDE OPERATING TEMPERATURE RANGE**
  - **— -40 to 70° C (HBCS-7100)**
  - **— -20 to 55° C (HBCS-7000)**
- **WIDE SCAN SPEED RANGE**
- **BLACK TEXTURED EPOXY FINISH**
- **DIGITAL OUTPUT**
  - **— Open Collector Output Compatible with TTL and CMOS Logic**
- **SINGLE 5 VOLT SUPPLY**



Description

Hewlett-Packard's Industrial Digital Slot Readers are designed to provide excellent scanning performance on a wide variety of bar coded cards and badges. They contain a unique optical/electrical system that integrates over a large area of the bar/space pattern, providing a greatly improved first read rate even on poorly printed bar codes.

The HBCS-7000 has a visible red (660 nm) optical system with a resolution of 0.19 mm (0.0075 in.). The HBCS-7100 model has an infrared (880 nm) optical system with a resolution of 0.19 mm (0.0075 in.).

The extra large depth of field allows these slot readers to have a slot width of 3.2 mm (0.125 in.), thus making it possible to read even multiple laminated cards and badges. When used as a stand alone optics module, the maximum depth of field is dependent on resolution.

The optics and electronics are housed in a rugged metal case. The cases are fully gasketed and sealed, making them suitable for use in outdoor or wet environments. The black epoxy coating adds a durable, finished look to these Digital Slot Readers. When installed using the rear screw holes, the units become tamper-proof, making them excellent choices for security access control.

The optical system is centered in the slot track, allowing the user to easily scan from either direction. The wide slot width makes it easy to insert and slide the cards. The optical system is covered with a recessed window to prevent contamination and reduce the wear on the cards.

The standard slot reader comes with the optical/electrical asembly mounted on a base plate with an opposite rail. A 122 cm (48 in.) straight cord and a 5 pin, 240 degree, locking DIN connector are also standard.

The optical/electrical system is also available as a separate unit which can be integrated into other equipment or used as a stand alone sensor assembly.

Applications

The digital bar code slot reader is a highly effective alternative to keyboard data entry. Bar code scanning is faster and more accurate than key entry and provides far greater throughput. In addition, bar code scanning typically has a higher first read rate and greater data accuracy than optical character recognition. When compared to magnetic stripe encoding, bar code offers significant advantages in flexibility of media, symbol placement and immunity to electromagnetic fields.

Hewlett-Packard's Industrial Digital Slot Readers are designed for applications where high first read rate and durability are important factors. The epoxy coated metal case, with its tamper-proof mounting system, makes these slot readers ideal choices for security access control, time and attendance recording and other bar coded badge and card reading applications.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Nominal Narrow Element Width				
HBCS-7000/7050		0.19 (0.0075)		mm (in.)
HBCS-7100/7150		0.19 (0.0075)		mm (in.)
Scan Velocity[1]	V_{SCAN}	20 (8)	317 (125)	cm/sec (in. sec/)
Contrast[2]	R_W-R_B	45		%
Supply Voltage[3]	V_S	4.5	5.5	Volts
Temperature[4]				
HBCS-7000/7050	T_A	-20	+55	°C
HBCS-7100/7150	T_A	-40	+70	°C
Ambient Light[5]	E_V		100,000	lux

Notes:
1. Measured scanning a symbol with 0.19 mm (0.0075 in.) narrow elements. For larger narrow element widths, the maximum scan velocity will increase proportionately.
2. Contrast is defined as R_W-R_B where R_W is the reflectance of the white spaces and R_B is the reflectance of the black bars, measured at the emitter wavelength (660 nm or 880 nm). Contrast is related to print contrast signal (PCS) by PCS = $(R_W-R_B)/R_W$ or R_W-R_B = PCS x R_W.
3. Power supply ripple and noise should be less than 100 mV peak to peak.
4. Non-condensing. If there is frost or dew covering over the optics window, it should be removed for optimal scanning performance.
5. Direct sunlight at any illumination angle.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units
Storage Temperature	T_S	-40	+80	°C
Supply Voltage	V_S	-0.3	+7.0	Volts
Output Transistor Power	P_T		200	mW
Output Collector Voltage	V_O	-0.3	+20	Volts

WARNING:
OBSERVING THE INFRARED LIGHT SOURCE IN THE HBCS-7150 AT CLOSE DISTANCES FOR PROLONGED PERIODS OF TIME MAY CAUSE INJURY TO THE EYE. When mounted with the rail in place, the infrared output flux is radiologically safe. With the rail removed, precautions should be taken to avoid exceeding the limits recommended in ANSI Z136.1-1981.

Electrical Operation

The HBCS-7XXX family of digital slot readers consists of a precision optical system, an analog amplifier, a digitizing circuit, and an output transistor. These elements provide a TTL compatible output from a single 4.5 V to 5.5 V DC power supply. The open collector transistor requires a pull-up resistor for proper operation.

A non-reflecting black bar results in a logic high (1) level output, while a reflecting white space will cause a logic low (0) level output. After power-up, the slot reader will be fully operational after a period of approximately 6 seconds. During operation, the slot reader will assume a logic low state after a short period (typically 1 second) if no bar code is scanned. This feature allows multiple scanners (both slot readers and Hewlett-Packard sapphire tip wands) to be connected together with a simple OR gate.

The slot reader connector provides a shield which should be terminated to logic ground or, preferably, to both logic ground and earth ground. The shield is connected to the metal housing of the 5 pin DIN connector, the metal housing of the slot reader, and logic ground inside the slot reader.

The recommended logic interface for the slot reader is shown in Figure 1. This interface provides ESD protection for both the slot reader and the user's electronics.

The maximum recommended cable length for the slot reader's output is 25 feet.

Electrical Characteristics (V_S = 4.5 V to 5.5 V, T_A = 25° C, unless otherwise noted)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Supply Current						
HBCS-7000/7050	I_S		50	100	mA	V_S = 5.0 V
HBCS-7100/7150	I_S		65	100	mA	V_S = 5.0 V
High Level Output Current	I_{OH}			1.0	μA	V_{OH} = 2.4 V
Low Level Output Voltage	V_{OL}			0.4	V	I_{OL} = 16 mA
Output Rise Time	t_r		0.9	5.0	μs	10%-90% Transition, R_L = 1K Ω
Output Fall Time	t_f		0.07	5.0	μs	
Electrostatic Discharge Immunity[6]	ESD		25		kV	

Notes:

6. Shield must be properly terminated (see Figure 1). The human body is modeled by discharging a 300 pF capacitor through a 500 Ω resistor. No damage to the slot reader will occur at the specified discharge level.

Interface Specifications

The slot readers include a standard 5 pin, 240°, metal, locking DIN connector. The recommended logic interface is shown in Figure 1. The mechanical specifications and wiring are shown in Figure 2. Mating connectors are available from SWITCHCRAFT in both 5 pin and 6 pin configurations. These connectors are listed on the right.

Connector	Configuration
SWITCHCRAFT 61HA5F	5 Pin
SWITCHCRAFT 13EL5F	5 Pin
SWITCHCRAFT 61HA6F	6 Pin

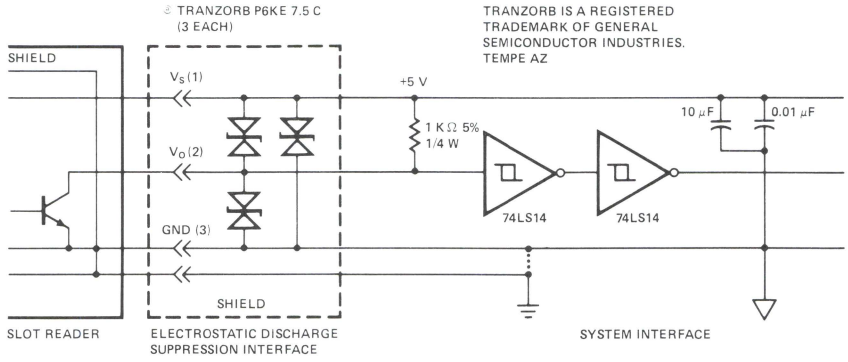
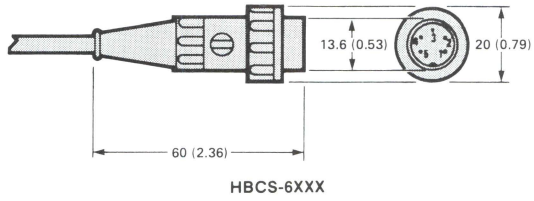


Figure 1. Recommended Logic Interface (When earth ground is not available, connect shield to logic ground, as shown by dotted line).



HBCS-6XXX

PIN	WIRE COLOR	FUNCTION
1	RED	V_S SUPPLY VOLTAGE
2	WHITE	V_O OUTPUT
3	BLACK	GROUND
4	N/A	N/C
5	N/A	N/C
CASE	-	SHIELD (MUST BE CONNECTED)

NOTES:
1. DIMENSIONS IN MILLIMETRES AND (INCHES).

Figure 2. Connector Specifications.

Mounting Considerations

Slot Reader

The slot reader (HBCS-7000/7100) is designed to be virtually tamper-proof when mounted using the two rear mounting holes. In this case, the cable must be routed from the rear of the slot reader through the mounting surface (wall, door, etc.). For applications where a tamper-proof installation is less of a concern, an optional mounting bracket (HBCS-7999) allows for more convenient surface mounting.

When mounting the slot reader, the cable may either be routed through the mounting surface (see above), or it may be routed along grooves in the base and exit the side of the slot reader at any one of four points. This allows flexibility in the mounting orientation.

Optics/Electronics Module

The optics/electronics module (HBCS-7050/7150) is designed for applications which require a different slot width, integration into a larger housing, or a fixed-beam stationary scanner. When using the optics/electronics module, the operating distance from the front surface of the module to the symbol will vary depending on the symbol resolution. Figure 3 shows the relationship between operating range and *minimum* symbol resolution for a typical optics/electronics module. This relationship was applied in the design of the slot reader, where a slot width of 3.2 mm (0.125 in.) insures excellent performance reading bar code symbols which have a *nominal* resolution of 0.19 mm (0.0075 in.) and include printing errors.

When mounting the optics/electronics module it is important that the screws be tightened with a minimum static torque of 2.5 Nm (22 in.-lbs.). This will insure that the sealing gasket is compressed sufficiently to provide proper sealing.

Rail

The rail (HBCS-7998) is designed for use with the optics/electronics module in applications which require a different slot width. It may also be used in applications where it is preferable to mount the optics/electronics module and rail flush to the mounting surface instead of using the base provided with the slot reader.

Mounting Bracket

The mounting bracket (HBCS-7999) is designed to provide a convenient way of mounting the slot reader, optics/electronics module, and/or rail to a flat surface.

Symbol Placement

The center of the slot reader's optical system is located 12.7 mm (0.50 in.) from the bottom of the slot. Consequently, bar code symbols to be read by the slot reader must be positioned on the card(s) or document(s) at a height which insures that all bars and spaces will cross a line located 12.7 mm (0.50 in.) from the bottom edge of the card(s) or document(s). For optimal performance, all bars and spaces should cross the area between 1.14 mm (0.45 in.) and 1.40 mm (0.55 in.) from the bottom edge of the card(s) or document(s).

The bars should be perpendicular to the bottom edge of the card(s) or document(s), however, a skew of ±4 degrees from the perpendicular is acceptable.

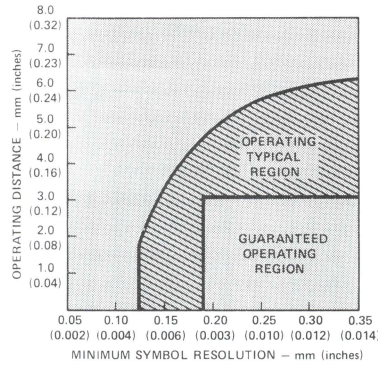


Figure 3. Typical Operating Distance vs. Minimum Symbol Resolution.

Maintenance Considerations

The slot reader and optics/electronics module include a window which is slightly recessed in order to prevent direct contact with the bar code symbol. This reduces wear on both the window and the symbol. The window may, however, become dirty over a period of time. If this occurs, clean the window with a commercial glass cleaner.

Testing

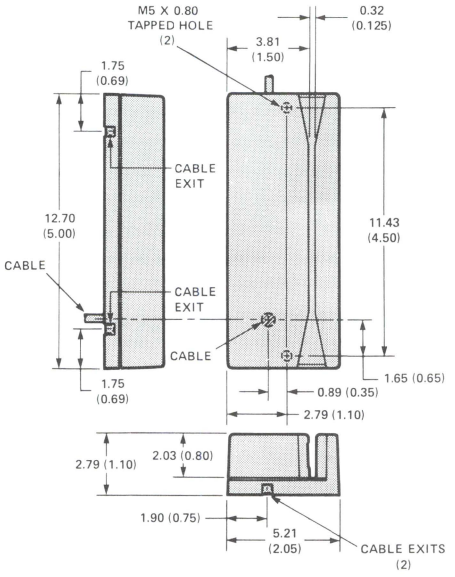
All Hewlett-Packard Digital Bar Code Slot Readers are 100% tested for performance and digitizing accuracy after manufacture. This insures a consistent quality product. More information about Hewlett-Packard's test procedures, test set-up, and test limits are available upon request.

Optional Features

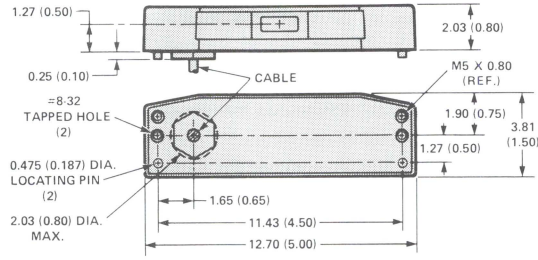
For options such as special cables or connectors, contact your nearest Hewlett-Packard sales office or authorized representative.

Dimensions

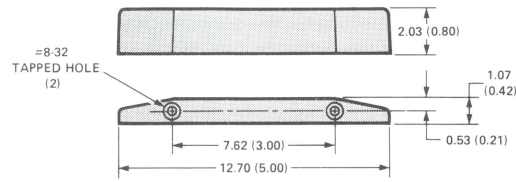
SLOT READER (HBCS-7000/7100)



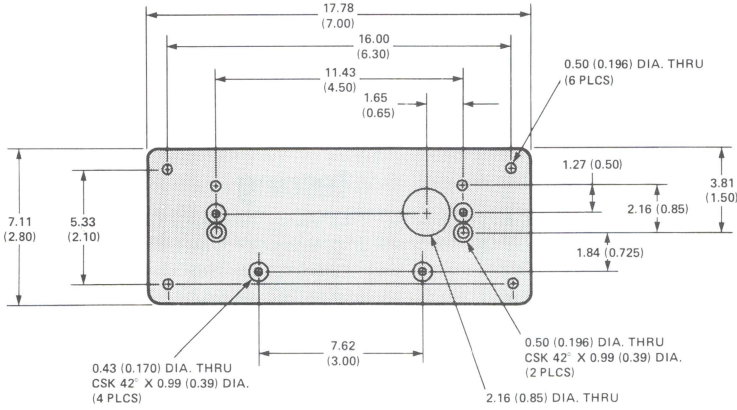
OPTICS/ELECTRONICS MODULE (HBCS-7050/7150)



RAIL (HBCS-7998)



MOUNTING BRACKET (HBCS-7999)



NOTES:
1. MOUNTING HOLES ON HBCS-7000/7100 ARE SUITABLE FOR EITHER =10-32 OR M5-0.80 SCREWS.
2. MOUNTING HOLES ON HBCS-7050/7150 ARE FOR =8-32 SCREWS.
3. MOUNTING HOLES ON HBCS-7998 ARE FOR =8-32 SCREWS.
4. THICKNESS OF THE HBCS-7999 MOUNTING BRACKET IS 3.2 mm (0.125 in.)
5. HBCS-7000/7100 SLOT READERS, HBCS-7050/7150 MODULES, AND HBCS-7998 RAILS HAVE A BLACK TEXTURED EPOXY FINISH. HBCS-7999 MOUNTING BRACKETS HAVE AN ELECTROLESS NICKEL FINISH.
6. ALL DIMENSIONS ARE NOMINAL AND ARE STATED IN MILLIMETRES AND (INCHES).

Selection Guide

Part Number	Description
HBCS-7000	Slot Reader with 660 nm visible red light source and 0.19 mm (0.0075 in.) nominal resolution.
HBCS-7100	Slot Reader with 880 nm infrared light source and 0.19 mm (0.0075 in.) nominal resolution.
HBCS-7050	Optics/Electronics Module with 660 nm visible red light source and 0.19 mm (0.0075 in.) nominal resolution.
HBCS-7150	Optics/Electronics Module with 880 nm infrared light source and 0.19 mm (0.0075 in.) nominal resolution.
HBCS-7998	Rail for use with the HBCS-7050/7150 (optional)
HBCS-7999	Mounting Bracket (optional)

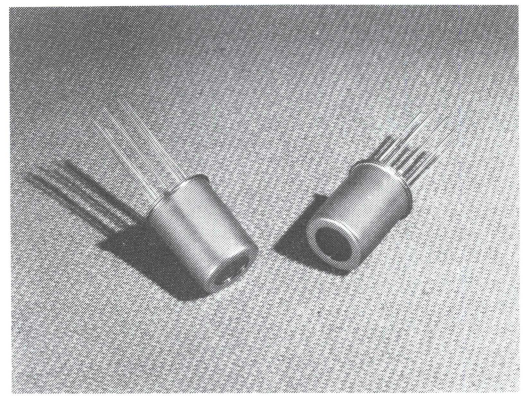
HEWLETT PACKARD

HIGH RESOLUTION OPTICAL REFLECTIVE SENSOR

HBCS-1100

Features

- **FOCUSED EMITTER AND DETECTOR IN A SINGLE PACKAGE**
- **HIGH RESOLUTION — .190mm SPOT SIZE**
- **700nm VISIBLE EMITTER**
- **LENS FILTERED TO REJECT AMBIENT LIGHT**
- **TO-5 MINIATURE SEALED PACKAGE**
- **PHOTODIODE AND TRANSISTOR OUTPUT**
- **SOLID STATE RELIABILITY**



Description

The HBCS-1100 is a fully integrated module designed for optical reflective sensing. The module contains a .178mm (.007 in.) diameter 700nm visible LED emitter and a matched I.C. photodetector. A bifurcated aspheric lens is used to image the active areas of the emitter and the detector to a single spot 4.27mm (0.168 in.) in front of the package. The reflected signal can be sensed directly from the photodiode or through an internal transistor that can be configured as a high gain amplifier.

Applications

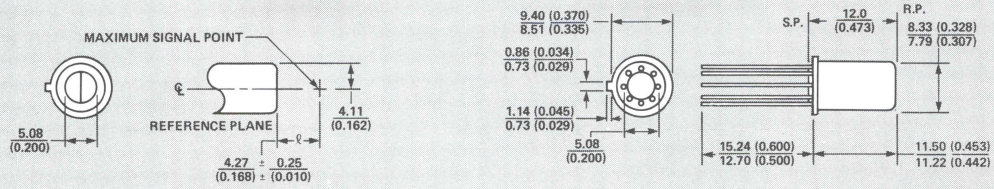
Applications include pattern recognition and verification, object sizing, optical limit switching, tachometry, textile thread counting and defect detection, dimensional monitoring, line locating, mark, and bar code scanning, and paper edge detection.

Mechanical Considerations

The HBCS-1100 is packaged in a high profile 8 pin TO-5 metal can with a glass window. The emitter and photodetector chips are mounted on the header at the base of the package. Positioned above these active elements is a bifurcated aspheric acrylic lens that focuses them to the same point.

The sensor can be rigidly secured by commercially available two piece TO-5 style heat sinks, such as Thermalloy 2205, or Aavid Engineering 3215. These fixtures provide a stable reference platform and their tapped mounting holes allow for ease of affixing this assembly to the circuit board.

Package Dimensions



NOTES:
1. ALL DIMENSIONS IN MILLIMETERS AND (INCHES).
2. ALL UNTOLERANCED DIMENSIONS ARE FOR REFERENCE ONLY.
3. THE REFERENCE PLANE IS THE TOP SURFACE OF THE PACKAGE.
4. NICKEL CAN AND GOLD PLATED LEADS.
5. S.P. SEATING PLANE.
6. THE LEAD DIAMETER IS 0.45mm (0.018in.) TYP.

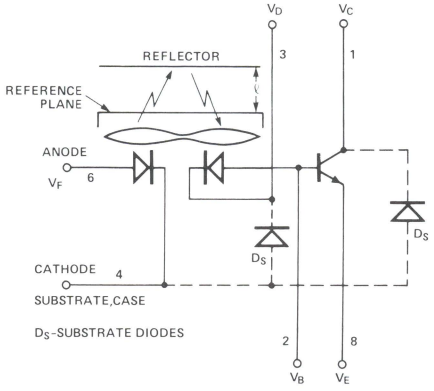
Electrical Operation

The detector section of the sensor can be connected as a single photodiode, or as a photodiode transistor amplifier. When photodiode operation is desired, it is recommended that the substrate diodes be defeated by connecting the collector of the transistor to the positive potential of the power supply and shorting the base-emitter junction of the transistor. Figure 15 shows photocurrent being supplied from the anode of the photodiode to an inverting input of the operational amplifier. The circuit is recommended to improve the reflected photocurrent to stray photocurrent ratio by keeping the substrate diodes from acting as photodiodes.

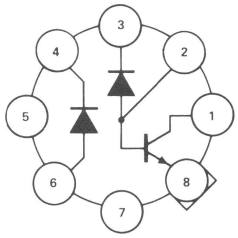
The cathode of the 700nm emitter is physically and electrically connected to the case-substrate of the device. Applications that require modulation or switching of the LED should be designed to have the cathode connected to the electrical ground of the system. This insures minimum capacitive coupling of the switching transients through the substrate diodes to the detector amplifier section.

The HBCS-1100 detector also includes an NPN transistor which can be used to increase the output current of the sensor. A current feedback amplifier as shown in Figure 6 provides moderate current gain and bias point stability.

SCHEMATIC DIAGRAM



CONNECTION DIAGRAM



TOP VIEW

PIN	FUNCTION
1	TRANSISTOR COLLECTOR
2	TRANSISTOR BASE, PHOTODIODE ANODE
3	PHOTODIODE CATHODE
4	LED CATHODE, SUBSTRATE, CASE
5	NC
6	LED ANODE
7	NC
8	TRANSISTOR EMITTER

Absolute Maximum Ratings at T_A=25°C

Parameter	Symbol	Min.	Max.	Units	Fig.	Notes
Storage Temperature	T_S	-40	+75	°C		
Operating Temperature	T_A	-20	+70	°C		
Lead Soldering Temperature 1.6mm from Seating Plane			260 for 10 sec.	°C		11
Average LED Forward Current	I_F		50	mA		2
Peak LED Forward Current	I_{FPK}		75	mA	1	1
Reverse LED Input Voltage	V_R		5	V		
Package Power Dissipation	P_P		120	mW		3
Collector Output Current	I_O		8	mA		
Supply and Output Voltage	V_D,V_C,V_E	-0.5	20	V		10
Transistor Base Current	I_B		5	mA		
Transistor Emitter Base Voltage	V_{EB}		.5	V		

CAUTION: The small junction sizes inherent to the design of this bipolar component increase the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be introduced by ESD.

System Electrical/Optical Characteristics at T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions	Fig.	Note
Total Photocurrent (I_{PR}+I_{PS})	I_P			575	nA	T_A=-20°C; I_F=35mA, V_D=V_C=5V	2,3	4
		150	250	375		T_A=25°C		
		80				T_A=70°C	15	
Reflected Photocurrent (I_{PR}) to Internal Stray Photocurrent (I_{PS})	$\frac{I_{PR}}{I_{PS}}$	4	8.5			I_F=35mA, V_C=V_D=5V	3	
Transistor DC Static Current Transfer Ratio	h_{FE}	50				T_A=-20°C; V_{CE}=5V, I_C=10μA	4,5	
		100	200			T_A=25°C		
Slew Rate			.08		V/μs	R_L=100K, I_{PK}=50mA; R_F= 10M, t_{ON}=100μs, Rate = 1kHz	6	
Image Diameter	d		.17		mm	I_F=35mA, ℓ=4.27mm (0.168in.)	8,10	8,9
Maximum Signal Point	ℓ	4.01	4.27	4.52	mm	Measured from Reference Plane	9	
50% Modulation Transfer Function	MTF		2.5		$I_{npr/mm}$	I_F=35mA, ℓ=4.27mm	10,11	5,7
Depth of Focus	$\frac{\Delta\ell}{FWHM}$		1.2		mm	50% of I_P at ℓ=4.27mm	9	5
Effective Numerical Aperature	N.A.		.3					
Image Location	D		.51		mm	Diameter Reference to Centerline ℓ=4.27mm		6
Thermal Resistance	Θ_{JC}		85		°C/W			

Detector Electrical/Optical Characteristics at T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions	Fig.	Note
Dark Current	I_{PD}		5	200	pA	T_A=25°C; I_F=0, V_D=5V; Reflection=0%		
				10	nA	T_A=70°C		
Capacitance	C_D		45		pF	V_D=0V, I_P=0, f=1MHz		
Flux Responsivity	$R\phi$		.22		$\frac{A}{W}$	λ=700nm, V_D=5V	12	
Detector Area	A_D		.160		mm^2	Square, with Length=.4mm/Side		

Emitter Electrical/Optical Characteristics at T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions	Fig.	Note
Forward Voltage	V_F		1.6	1.8	V	I_F=35mA	13	
Reverse Breakdown Voltage	BV_R	5			V	I_R=100μA		
Radiant Flux	ϕ_E	5	9.0		μW	I_F=35mA, λ=700nm	14	
Peak Wavelength	λ_p	680	700	720	nm	I_F=35mA	14	
Thermal Resistance	Θ_{JC}		150		°C/W			
Temperature Coefficient of V_F	$\Delta V_F/\Delta T$		-1.2		mV/°C	I_F=35mA		

Transistor Electrical Characteristics at T_A=25°C

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions	Fig.	Note
Collector-Emitter Leakage	I_{CEO}		1		nA	V_{CE}=5V		
Base-Emitter Voltage	V_{BE}		.6		V	I_C=10μA, I_B=70nA		
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$		.4		V	I_B=1μA, I_E=10μA		
Collector-Base Capacitance	C_{CB}		.3		pF	f=1MHz, V_{CB}=5V		
Base-Emitter Capacitance	C_{BE}		.4		pF	f=1MHz, V_{BE}=0V		
Thermal Resistance	Θ_{JC}		200		°C/W			

NOTES:
1. 300μs pulse width, 1 kHz pulse rate.
2. Derate Maximum Average Current linearly from 65°C by 6mA/°C.
3. Without heat sinking from T_A = 65°C, derate Maximum Average Power linearly by 12mW/°C.
4. Measured from a reflector coated with a 99% reflective white paint (Kodak 6080) positioned 4.27mm (0.168 in.) from the reference plane.
5. Peak-to-Peak response to black and white bar patterns.
6. Center of maximum signal point image lies within a circle of diameter D relative to the center line of the package. A second emitter image (through the detector lens) is also visible. This image does not affect normal operation.
7. This measurement is made with the lens cusp parallel to the black-white transition.
8. Image size is defined as the distance for the 10%-90% response as the sensor moves over an abrupt black-white edge.
9. (+) indicates an increase in the distance from the reflector to the reference plane.
10. All voltages referenced to Pin 4.
11. CAUTION: The thermal constraints of the acrylic lens will not permit the use of conventional wave soldering procedures. The typical preheat and post cleaning temperatures and dwell times can subject the lens to thermal stresses beyond the absolute maximum ratings and can cause it to defocus.

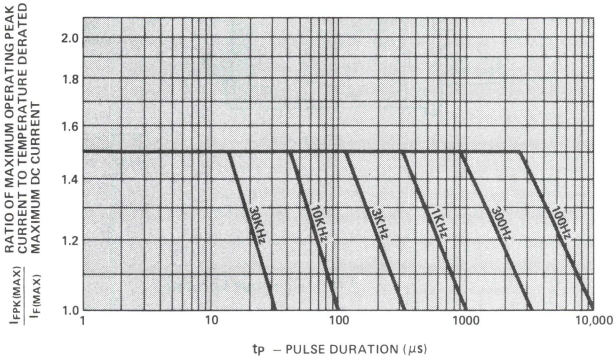


Figure 1. Maximum Tolerable Peak Current vs. Pulse Duration

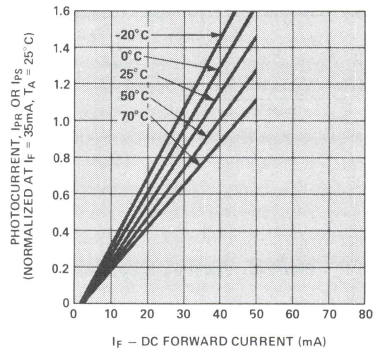


Figure 2. Relative Total Photocurrent vs. LED DC Forward Current

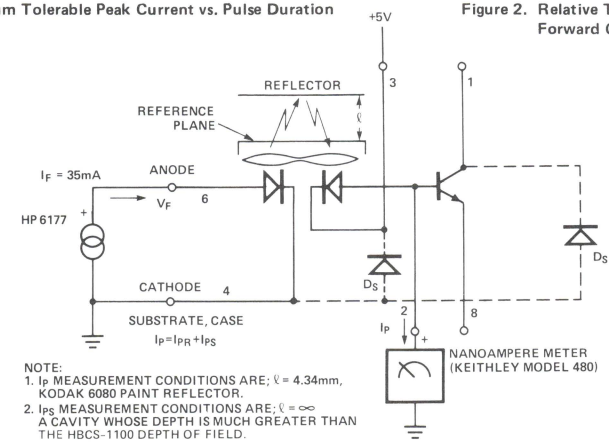


Figure 3. Ip Test Circuit

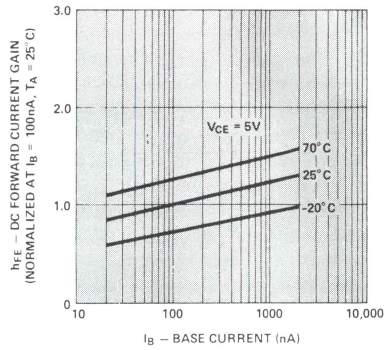


Figure 4. Normalized Transistor DC Forward Current Gain vs. Base Current at Temperature

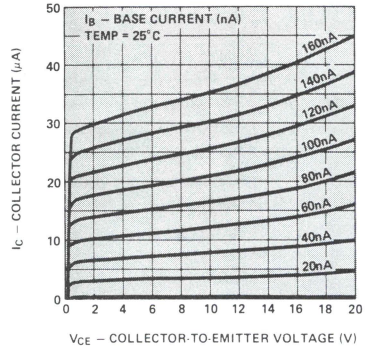


Figure 5. Common Emitter Collector Characteristics

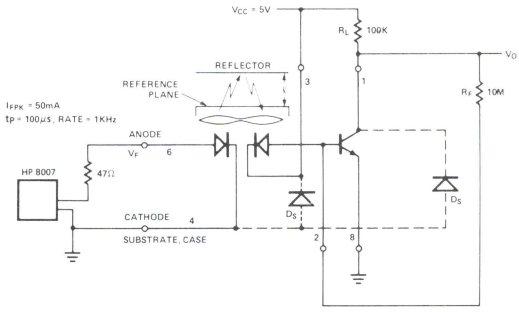


Figure 6. Slew Rate Measurement Circuit

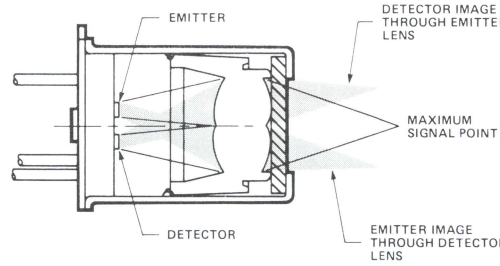


Figure 7. Image Location

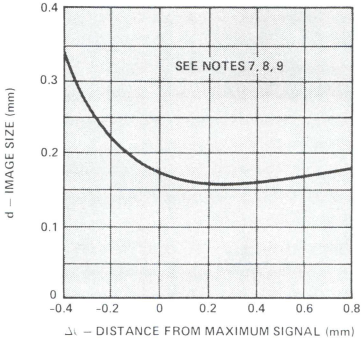


Figure 8. Image Size vs. Maximum Signal Point

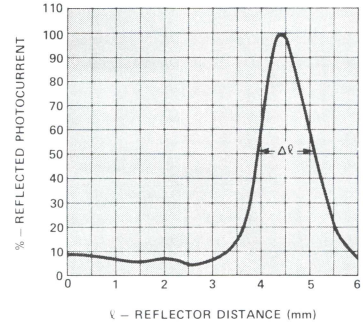


Figure 9. Reflector Distance vs. % Reflected Photocurrent

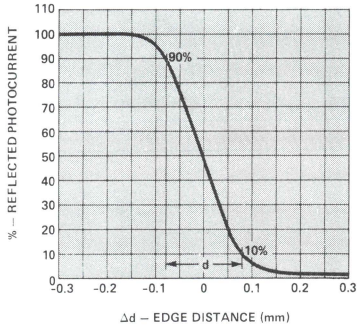


Figure 10. Step Edge Response

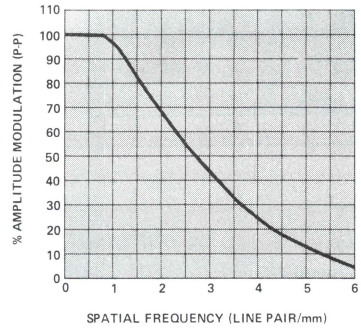


Figure 11. Modulation Transfer Function

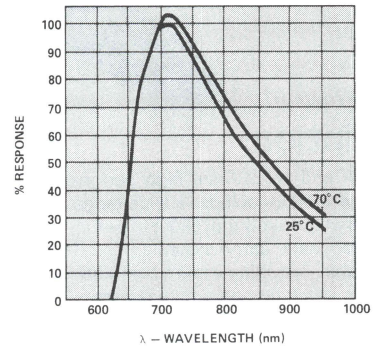


Figure 12. Detector Spectral Response

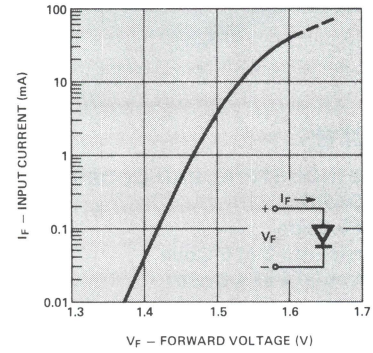


Figure 13. LED Forward Current vs. Forward Voltage Characteristics

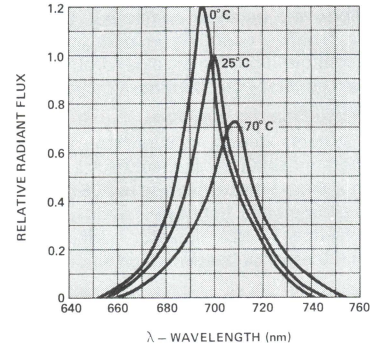


Figure 14. Relative Radiant Flux vs. Wavelength

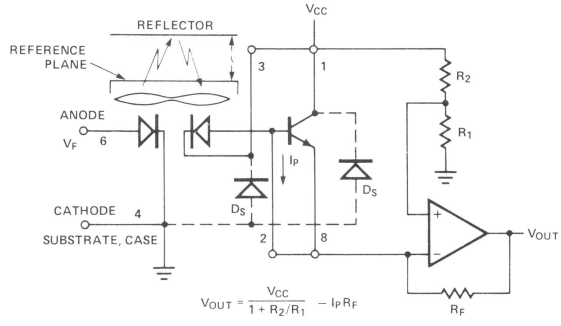
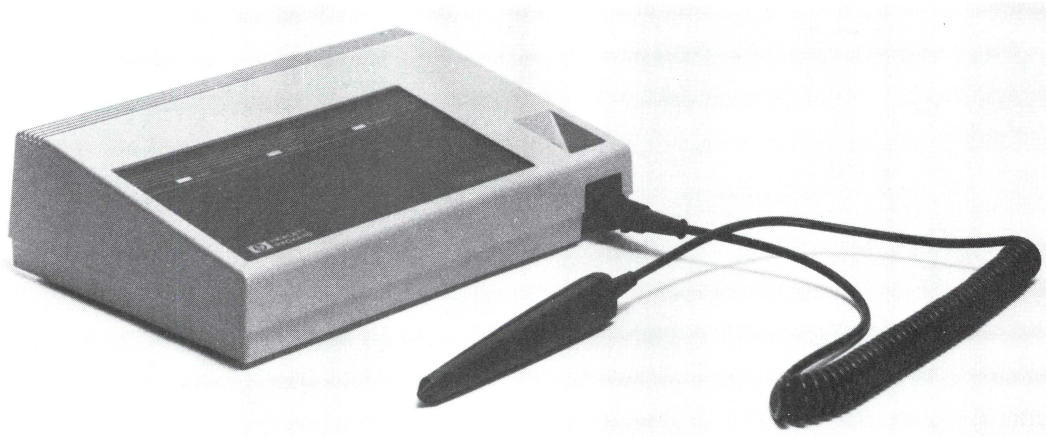


Figure 15. Photodiode Interconnection

HEWLETT PACKARD

BAR CODE READERS

16800A
16801A



Features

- **THREE INDUSTRIAL BAR CODES STANDARD:**
  - **— 3 of 9 Code**
  - **— Interleaved 2 of 5 Code**
  - **— Industrial 2 of 5 Code**
- **AUTOMATIC CODE RECOGNITION**
- **OPTIONAL BAR CODES AVAILABLE**
  - **— UPC/EAN/JAN**
  - **— Codabar**
  - **— Others**
- **FLEXIBLE DUAL RS-232-C (V.24) DATA COMMUNICATIONS**
  - **— Facilitates a Wide Variety of Configurations**
- **PROGRAMMABLE OPERATION (16800A only):**
  - **— Two LED Status Indicators**
  - **— Beeper Control**
  - **— Code Selection**
  - **— Data Communication Configuration**
  - **— Reader Operational Status**
- **HIGH PERFORMANCE DIGITAL WANDS:**
  - **— 45 Degree Scan Angle**
  - **— Sealed Sapphire Tip**
  - **— Polycarbonate or Metal Case**
- **INTEGRAL POWER SUPPLY**
- **TABLETOP OR WALL MOUNTABLE**
- **BUILT-IN SELF TEST**
- **WORLDWIDE HP SERVICE**

Description

The 16800A and 16801A are high performance bar code readers. The 16800A includes a wide range of programmable features which allow the reader to be fully integrated into sophisticated data entry systems. The 16801A is non-programmable, providing a more cost-effective solution for applications which do not require programmability.

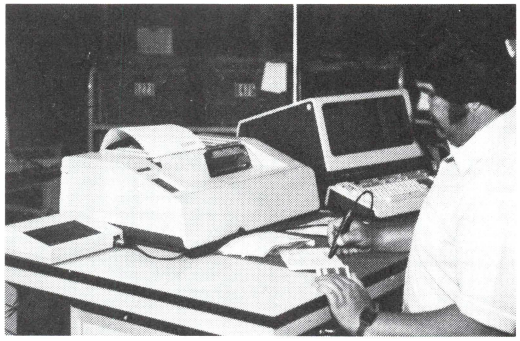
The standard reader supports three popular industrial bar codes: 3 of 9 code, Interleaved 2 of 5 code, and Industrial 2 of 5 code. If more than one standard code is enabled, the reader will automatically recognize which code is being read. Options are available for reading UPC/EAN/JAN codes, Codabar code, and other bar codes. Bidirectional scanning is provided for all bar codes supported.

The 16800A and 16801A may be configured with a wide range of computer systems; including minicomputers, desktop computers, and personal computers. Dual RS-232-C (V.24) ports facilitate operation in both stand-alone and eavesdrop configurations. In an eavesdrop configuration, the reader will generally be operated in conjunction with an RS-232-C terminal.

Interactive systems design is supported in the 16800A through programmable operator feedback and reader control features. A multi-tone beeper and two LED indicators are provided to allow simple, yet flexible audio and visual programmable feedback. Local operator feedback is provided in the 16801A through a beeper which sounds to signify a good read.

Reader performance can be optimized by selecting the wand appropriate for the environment and the type of symbol being read. The wands offer a 45 degree scan angle, a rugged case, and a sealed sapphire tip. The sapphire tip may be replaced by the user if it is damaged.

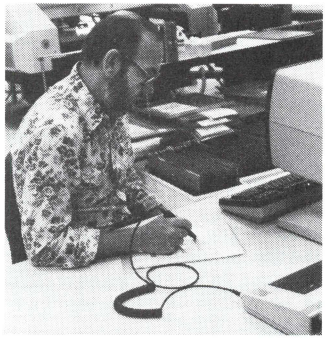
Applications



Bar codes offer a method of entering data into computers which is fast, accurate, reliable, and which requires little operator training. Implementation of a bar code system can lead to increased productivity, reduced inventory costs, improved accountability, increased asset visibility, and reduced paperwork. Customer satisfaction will also improve as a result of improved quality control, reduced shipping errors, and reduced order and ship times. On-line, real-time interactive systems will allow the user to take full advantage of the contributions offered by bar code systems. The 16800A and 16801A provide a high performance solution for applications which require on-line bar code data entry.

The most common type of data stored in bar code is item identification information used in a wide range of applications such as:

— Inventory Control
— Work-in-Process Tracking
— Distribution Tracking
— Order Processing
— Records Management
— Point-of-Sale
— Government Packaging and Shipping

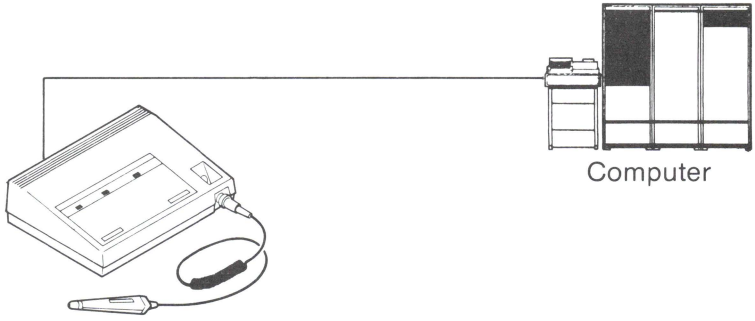


Bar codes can also be used in applications where information about an item or a transaction must be accurately entered into the host computer. Item location, employee identification, work steps, equipment settings, equipment status, and inspection results are some of the types of information which can be entered using bar codes.

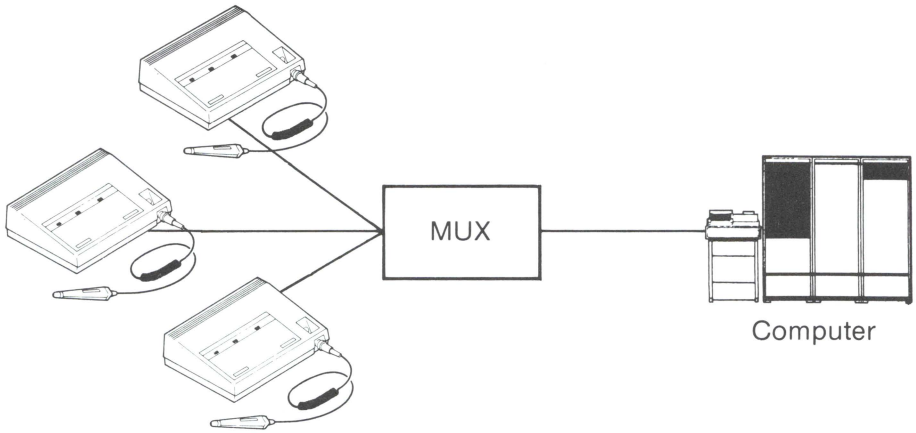
Typical Configuration

The dual RS-232-C (V.24) output provided by the 16800A and 16801A allows a single reader to be configured in a wide range of on-line applications. Three typical system configurations are outlined below:

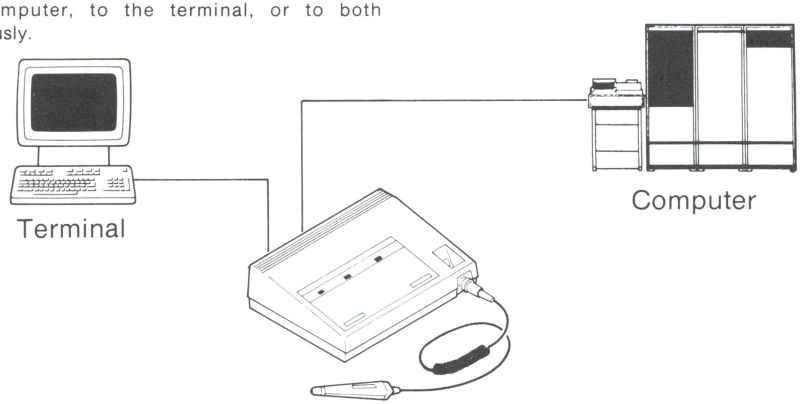
- **Stand-Alone Reader** — The 16800A/16801A is in direct communication with the host minicomputer, desktop computer, or personal computer.



- **Multiplexed** — A cluster of 16800A/16801As communicates with the host computer through a multiplexer. Where the advantages of fiber optic data communications are desired, the Hewlett-Packard 39301A Fiber Optic Multiplexer can be used.



- **Eavesdrop** — The 16800A/16801A is in an eavesdrop configuration between an RS-232-C terminal and the host computer. The reader can be configured to transmit to the computer, to the terminal, or to both simultaneously.



Wand Selection

The 16800A and 16801A bar code readers include HBCS-5300 digital bar code wand which is capable of reading bar code symbols which have nominal narrow bar/space widths of 0.19 mm (0.0075 in.) or greater. This includes a wide range of high, medium, and low resolution bar codes including standard 3 of 9 code [0.19 mm (0.0075 in.)].

An optional HBCS-5500 digital bar code wand is available for very high resolution codes with nominal narrow bar/space widths of 0.13 mm (0.005 in.) to 0.20 mm (0.008 in.). The 820 nm near-infrared emitter in the HBCS-5500 wand also enables it to read the black-on-black bar codes used in some security systems. This wand is not recommended for dot matrix printed bar codes or colored bar codes.

The HBCS-5000 series wands feature a rugged polycarbonate case designed for light industrial and commercial applications. Applications which require an industrial wand are supported by the optional HBCS-6300 and HBCS-6500 digital bar code wands. These wands feature a solid metal case and internal construction designed for abusive environments. The HBCS-6300 and HBCS-6500 have the same bar code reading characteristics as the HBCS-5300 and HBCS-5500, respectively.

All wands are also available under accessory product numbers.

Code Selection

The 16800A and 16801A offer user flexibility in the implementation of the three standard bar codes:

- Single Code Selection or Automatic Code Recognition (any combination of the three standard codes)
- Checksum Verification Selectable
- Variable Message Length up to 32 characters

- Selectable Message Length Check (Interleaved 2 of 5 code and Industrial 2 of 5 code)
- Any specified code resolution

Optional bar codes will also provide a high degree of user flexibility. The code reading configuration is switch selectable. Additional information on bar code symbologies is available in the Operating and Installation Manual and in Application Note 1013 — "Elements of a Bar Code System".

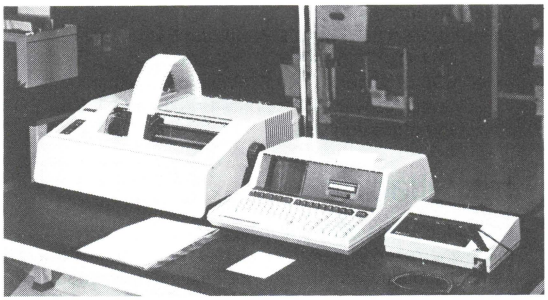
16800A Additional Capabilities
The 16800A offers the advantage of programmable control over all aspects of the code reading configuration. This capability enables the applications software to determine what code can be read depending on the type of data to be entered. For example, the 3 of 9 code could be enabled for entering item identification information and then the 3 of 9 code disabled and Interleaved 2 of 5 code enabled for entering a different type of data such as employee identification or job status. This allows different bar codes to be used in the system while at the same time preventing the operator from entering the wrong type of data into the data base.

Data Communications

The 16800A and 16801A provide a flexible dual RS-232-C (V.24) serial ASCII data communications capability which can support a wide range of system configurations. The reader offers the user the choice of full or half duplex transmission when in character mode and, if in an eavesdrop configuration with a terminal, the reader can also be operated in block mode. The user can tailor the reader's data communication configuration to the application by selecting the appropriate transmission mode (full/half duplex), operating mode (character/block mode), data rate, parity, terminator, stop bits, and inter-character delay on the readily accessible DIP switches. Request to Send/Clear to Send and DC1/DC3 (XON/XOFF) traffic control is available.

16800A Additional Capabilities
The 16800A offers expanded data communications capabilities with the added benefit of programmable control. In addition to programmable control of the transmission mode (full/half duplex) and the operating mode (character/block mode), the 16800A provides the following programmable features:

- User-definable header (up to 10 characters)
- User-definable terminator (up to 10 characters)
- DC1/DC3 (XON/XOFF) traffic control enable/disable



Operator Feedback

The 16800A and 16801A provide good read feedback to the operator by sounding an integral beeper. Beeper volume can be adjusted as appropriate for the application.

16800A Additional Capabilities
Interactive operator feedback is provided in the 16800A through two programmable LED indicators and programmable beeper control. The user has programmable control over operator feedback as follows:

- Local good read beep enable/disable
- Local good read beep tone (16 tones available)
- Computer commanded beep (16 tones available)
- Red LED Indicator on/off
- Green LED Indicator on/off

Programmable operator feedback can be used to prompt the operator, to signify that data has been validated by the computer, to differentiate between different workstations in close proximity, to provide additional LED feedback in extremely noisy environments, or for a variety of other reasons.

Reader Control and Status (16800A only)

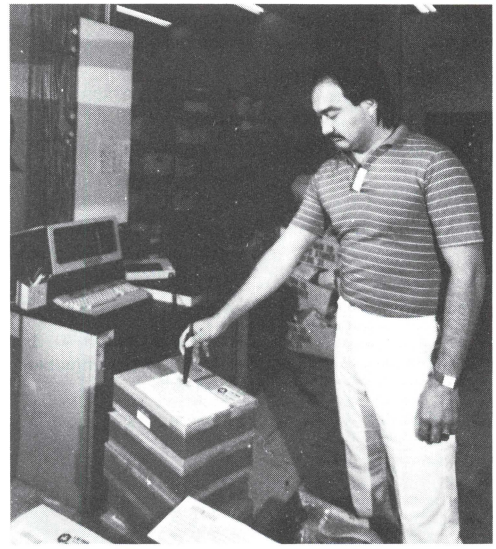
The 16800A provides the user with added programmable control over the reader's operation and also enables the user to obtain on-line status information regarding the reader's configuration and functionality. The programmable control and status features are described below:

Scanner Enable/Disable — When disabled, further bar code scans are ignored.

Single Read Enable/Disable — When enabled, a single bar code scan can be entered between "Next Read" commands.

Hard Reset — Commands the reader to return to the operating configuration prescribed by the DIP switch settings. An automatic self-test is also executed.

Status Request — Commands the reader to send the status of its operating configuration to the computer.



Specifications

General

Typical Wand Reading Characteristics:

Parameter	Units	HBCS-5300 or HBCS-6300	HBCS-5500 or HBCS-6500
Minimum Recommended Nominal Narrow Element Width	mm in.	0.190 0.0075	0.127 0.005
Tilt Angle	degrees	0-45	0-45
Scan Speed	cm/sec in./sec	7.6-127 3-50	7.6-127 3-50
Wavelength	nm	655	820

Bar Codes Supported:

Standard: 3 of 9 Code (ANSI MH10.8M-1983; MIL-STD-1189)
Interleaved 2 of 5 Code (ANSI MH10.8M-1983)
Industrial 2 of 5 Code

Optional: UPC/EAN/JAN (Option 001)
Codabar (Option 002)
Others (contact factory)

Data Communications

Data Rate:	110, 300, 600, 1200, 2400, 4800, 9600 baud. Switch Selectable.
Parity:	0's, 1's, Odd, Even. Switch Selectable.
Terminator:	CR, CR/LF, Horizontal Tab (HT), None. Switch Selectable.
Programmable Header/ Terminator (16800A only):	User defined. Maximum of 10 characters each.
Stop Bits:	1 or 2. Switch Selectable.
Inter-Character Delay:	30 ms or None. Switch Selectable.
Standard Asynchronous Communications Interface:	EIA Standard RS-232-C (CCITT V.24)
Transmission Modes:	Full or half duplex, asynchronous. Switch selectable. Programmable in 16800A.
Operating Modes:	Character or Block Mode. Switch selectable. Programmable in 16800A.
Traffic Control:	Request to Send/Clear to Send. DC1/DC3 (XON/XOFF). Switch Selectable. Programmable in 16800A.
Output Buffer:	255 Characters

Environmental Conditions

Temperature, Free Space Ambient:	
Non-Operating:	-40 to 75° C (-40 to +167° F)
Operating:	0 to +55° C (+32 to 131° F)
Humidity:	5 to 95% (non-condensing)
Altitude:	
Non-Operating:	Sea level to 15300 metres (50,000 feet)
Operating:	Sea level to 4600 metres (15,000 feet)
Vibration:	0.38 mm (0.015 in.) p-p, 5 to 55 to 5 Hz, 3 axis
Shock:	30g, 11 ms, 1/2 sine

Physical Specifications

Weight, including wand:	2.0 kg (4.4 pounds)
Weight, polycarbonate wand only: (including coiled cord)	0.13 kg (0.3 pounds)
Weight, industrial wand only: (including coiled cord)	0.16 kg (0.4 pounds)
Reader Dimensions:	260 mmW x 189 mmD X 71 mmH (10.25 in.W x 7.4 in.D x 2.8 in.H)
Polycarbonate Wand Dimensions:	134 mmW x 23 mmD x 20 mmH (5.3 in.W x 0.9 in.D x 0.8 in.H)
Industrial Wand Dimensions:	158 mmW x 24 mmD x 18 mmH (6.2 in.W x 0.9 in.D x 0.7 in.H)
Wand Cord Length:	94 cm (37 in.) — retracted 206 cm (81 in.) — extended

Power Requirements

Input Voltage:	100V (+5%, -10%) at 48-66 Hz (Opt. 210) 120V (+5%, -10%) at 48-66 Hz (Standard) 220V (+5%, -10%) at 48-66 Hz (Opt. 222) 240V (+5%, -10%) at 48-66 Hz (Opt. 224)
Power Consumption:	20 VA maximum

Regulatory Agency Approvals

RFI/EMI:

- — VDE 0871 level B
- — FCC Class B

Safety Approvals:

- — UL478, UL114 for EDP and office equipment
- — CSA C22.2-154 for EDP equipment
- — VDE 0730 part 2P for EDP and office equipment
- — Complies with IEC standard #380 and #435 for EDP and office equipment

Installation

All product preparation and installation can be performed by the owner/user. Refer to the Operating and Installation Manual supplied with the unit for detailed instructions.

Supporting Literature

For further information refer to:

16800A/16801A Option 001 Data Sheet, Publication Number 5954-2156 (Available through local sales office)

16800A/16801A Option 002 Data Sheet, Publication Number 5954-2157 (Available through local sales office)

16800A/16801A Operating and Installation Manual, P/N: 16800-90001

16800A/16801A Option 001 Operating and Installation Manual Addendum, P/N: 16800-90004

16800A/16801A Option 002 Operating and Installation Manual Addendum, P/N: 16800-90006

Application Note 1013, "Elements of a Bar Code System", Publication Number: 5953-7732 (Available through local sales office)

Application Bulletin 59, "HP 16800A/16801A Bar Code Reader Configuration Guide for a DEC VT-100 or Lear Siegler ADM-31 to a DEC PDP-11 Computer", Publication Number: 5953-9365 (Available through local sales office)

Application Bulletin 61, "HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 3276/3278 Terminal", Publication Number: 5953-9361 (Available through local sales office)

Application Bulletin 62, "HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 4955F Series 1 Process Control CPU/Protocol Converter and an IBM 3101 Terminal", Publication Number: 5953-9362 (Available through local sales office)

Application Bulletin 63, "HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 5101 Personal Computer", Publication Number: 5953-9363 (Available through local sales office)

Application Bulletin 68, "HP 16800A/16801A Bar Code Reader Configuration Guide for a MICOM Micro 280 Message Concentrator", Publication Number: 5953-9382 (Available through local sales office)

Ordering Information

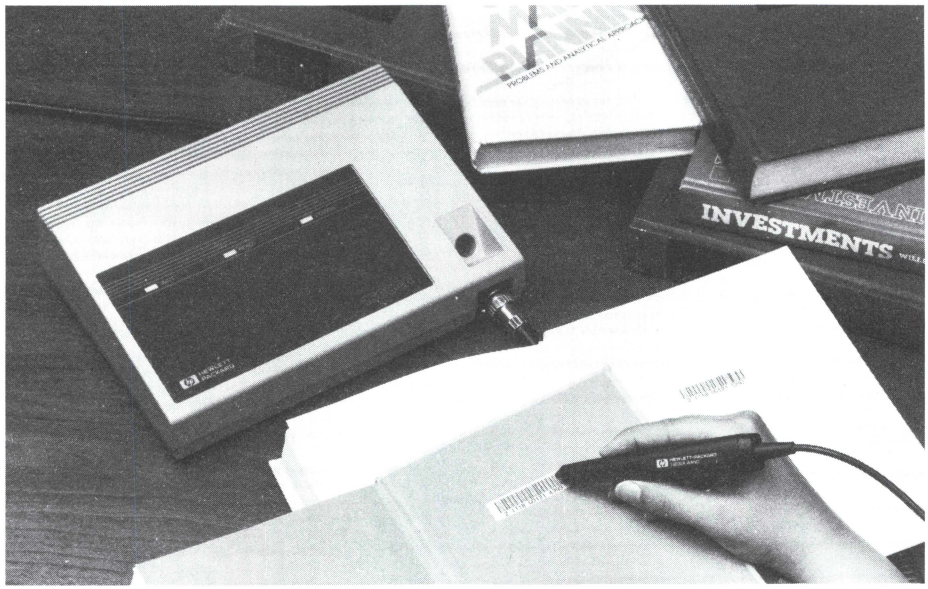
PRODUCT NO.	DESCRIPTION
16800A	PROGRAMMABLE BAR CODE READER — Includes HBCS-5300 digital wand, internal power supply for 120V line voltage, power cord, and Operating and Installation Manual. Reader supports 3 of 9 Code, Interleaved 2 of 5 Code, and Industrial 2 of 5 Code.
16801A	BAR CODE READER — Includes HBCS-5300 digital wand, internal power supply for 120V line voltage, power cord, and Operating and Installation Manual. Reader supports 3 of 9 Code, Interleaved 2 of 5 Code, and Industrial 2 of 5 Code.
-001	Add UPC/EAN/JAN code reading capability; Delete Industrial 2 of 5 code
-002	Add Codabar code reading capability; Delete Industrial 2 of 5 code
-210	100V power supply
-222	220V power supply
-224	240V power supply
-320	Delete HBCS-5300 digital wand; Add HBCS-5500 ditigal wand
-400	Delete HBCS-5300 digital wand; Add HBCS-6300 industrial digital wand
-420	Delete HBCS-5300 digital wand; Add HBCS-6500 industrial digital wand
-610	Add Wall Mounting Kit
-910	Additional Operating and Installation Manual
ACCESSORIES	
16830A	General Purpose Digital Bar Code Wand
16832A	High Resolution Digital Bar Code Wand
16840A	Industrial (Metal) General Purpose Bar Code Wand
16842A	Industrial (Metal) High Resolution Bar Code Wand
HBCS-2999	HBCS-5300/5500 Replacement Sapphire Tip
HBCS-4999	HBCS-6300/6500 Replacement Sapphire Tip
16800-61000	Wall Mount Kit
HEDS-0200	20 foot Wand Extension Cord
03075-40006	External Wand Holder
17355A	2.7 metres (9 feet) Male-Male RS-232-C cable. Shielded.
LITERATURE	
16800-90001	Operating and Installation Manual
16800-90004	Option 001 Operating and Installation Manual Addendum
16800-90006	Option 002 Operating and Installation Manual Addendum

HEWLETT PACKARD

CODABAR BAR CODE READERS

16800A OPTION 002

16801A OPTION 002



Features

- **CODABAR CODE READING CAPABILITY**
- **TWO STANDARD INDUSTRIAL BAR CODES**
  - **— 3 of 9 Code**
  - **— Interleaved 2 of 5 Code**
- **AUTOMATIC CODE RECOGNITION**
- **HIGH PERFORMANCE DIGITAL WANDS**
  - **— 45 Degree Scan Angle**
  - **— Replaceable, Sealed, Sapphire Tip**
  - **— Polycarbonate or Metal Case**

Description

Option 002 adds bar code reading capability for Codabar to the HP16800A Programmable Bar Code Reader and HP16801A Non-Programmable Bar Code Reader. Transmission of the start and stop characters which are part of each Codabar symbol is user-selectable.

Two standard industrial codes, the 3 of 9 code and Interleaved 2 of 5 code, may also be read with Option 002. These two codes may be enabled individually, simultaneously, and/or in conjunction with the Codabar code.

Industrial 2 of 5 code reading capability, available with the standard HP16800A and HP16801A, is not provided with Option 002.

Applications

Codabar code is commonly used for material tracking, customer identification, and traceability in four specific application areas:

— Libraries
— Hospitals
— Film Processing
— Package Tracking

The 3 of 9 code is also popular in these applications, especially where an alphanumeric code is preferred. In some circumstances, both the 3 of 9 code and Codabar code may need to be read interchangeably. This capability is provided by the automatic code recognition feature of the HP16800A and HP16801A.

The 3 of 9 code and Interleaved 2 of 5 code are generally preferred in industrial applications and in applications which involve interfacility or intercompany movement of goods. These applications include:

— Inventory control
— Work-in-process tracking
— Distribution tracking
— Records management
— Government packaging and shipping
— Labor reporting
— Asset management

Wand Selection

The HP 16800A and HP 16801A Bar Code Readers include an HBCS-5300 digital bar code wand which is capable of reading bar code symbols which have nominal narrow bar/space widths of 0.19 mm (0.0075 in.) or greater. This wand is recommended for reading all low resolution bar codes, such as those produced with dot matrix printers, and for reading high resolution 3 of 9 and Interleaved 2 of 5 bar codes. It may also be used to read most high resolution Codabar symbols.

An optional HBCS-5500 digital bar code wand is available for very high resolution codes have nominal narrow bar/space widths of 0.13 mm (0.005 in.) to 0.20 mm (0.008 in.). This wand may provide superior performance when reading high resolution Codabar symbols since this code has a nominal narrow bar width of 0.17 mm (0.0065 in.). An 820 nm near-infrared emitter enables the HBCS-5500 to read black-and-white bar codes and the black-on-black bar codes used in some security systems.

Applications which require an industrial wand are supported by the optional HBCS-6300 and HBCS-6500 digital bar code wands. These wands feature a solid metal case and internal construction designed for abusive environments. The HBCS-6300 and HBCS-6500 have the same bar code reading characteristics as the HBCS-5300 and HBCS-5500, respectively.

Supporting Literature

For further information refer to:

16800A/16801A Option 002 Operating and Installation Manual Addendum, P/N: 16800-90006

16800A/16801A Operating and Installation Manual, P/N: 16800-90001

16800A/16801A Data Sheet, Publication No: 5954-2155

Ordering Information

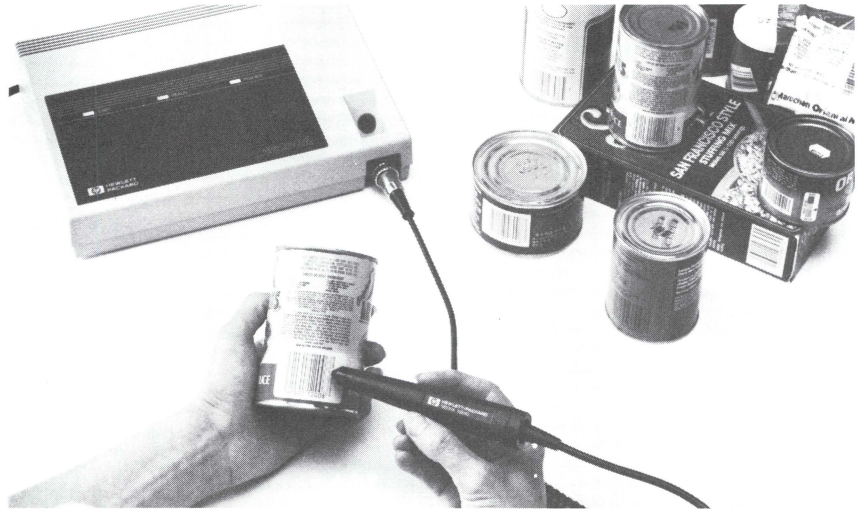
Product Number	Description
16800A	Programmable Bar Code Reader
-002	Includes HBCS-5300 digital wand, internal power supply for 120 V line voltage, power cord, and Operating and Installation Manuals. Reader supports Codabar, 3 of 9, and Interleaved 2 of 5 codes.
16801A	Non-Programmable Bar Code Reader
-002	Includes HBCS-5300 digital wand, internal power supply for 120 V line voltage, power cord, and Operating and Installation Manuals. Reader supports Codabar, 3 of 9, and Interleaved 2 of 5 codes.
-210	100V Power Supply
-222	220V Power Supply
-224	240V Power Supply
-320	Delete HBCS-5300 digital wand; add HBCS-5500 ditigal wand
-400	Delete HBCS-5300 digital wand; add HBCS-6300 industrial digital wand
-420	Delete HBCS-5300 digital wand; add HBCS-6500 industrial digital wand
-610	Add Wall Mounting Kit
-910	Additional Operating and Installation Manuals

HEWLETT PACKARD

UPC/EAN/JAN BAR CODE READERS

16800A
OPTION 001

16801A
OPTION 001



Features

- **FLEXIBLE COMMERCIAL CODE READING CAPABILITY**
  - **— UPC-A, UPC-E**
  - **— EAN-8, EAN-13**
  - **— JAN-8, JAN-13**
  - **— 2-Digit Supplemental Encodation**
  - **— 5-Digit Supplemental Encodation**
- **TWO STANDARD INDUSTRIAL BAR CODES**
  - **— 3 of 9 Code**
  - **— Interleaved 2 of 5 Code**
- **AUTOMATIC CODE RECOGNITION**
- **COMPATIBLE WITH UPC SHIPPING CONTAINER SYMBOL SPECIFICATION**
- **HIGH PERFORMANCE DIGITAL WANDS**
  - **— 45 Degree Scan Angle**
  - **— Replaceable, Sealed, Sapphire Tip**
  - **— Polycarbonate or Metal Case**

Description

Option 001 adds bar code reading capability for the Universal Product Code (UPC), European Article Numbering Code (EAN), and Japanese Article Numbering Code (JAN) to the HP 16800A Programmable Bar Code Reader and HP 16801A Non-Programmable Bar Code Reader.

All popular versions of the UPC, EAN and JAN bar codes may be enabled, including UPC-A, UPC-E, EAN-8, EAN-13, JAN-8 and JAN-13. All codes may be read simultaneously, or only UPC-A and UPC-E may be enabled.

UPC, EAN, and JAN codes with complementary 2-digit or 5-digit supplemental encodations, or "add-ons", may be read in one of two ways. If UPC, EAN, and JAN codes are enabled but neither 2-digit nor 5-digit supplemental encodations are enabled, then symbols printed with, or without, supplements can be read and only the main symbol will be output. If 2-digit (or 5-digit) supplemental encodations are enabled, then only symbols with 2-digit (or 5-digit) supplements can be read and both the main symbol and the supplement are output. 2-digit and 5-digit supplemental encodations may be enabled simultaneously.

Two standard industrial codes, the 3 of 9 code and Interleaved 2 of 5 code, may also be read with Option 001. These two codes may be enabled individually, simultaneously, and/or in conjunction with the UPC, EAN, and JAN codes. The implementation of the Interleaved 2 of 5 code is compatible with the UPC Shipping Container Symbol Specification.

Industrial 2 of 5 code reading capability, available with the standard HP 16800A and HP 16801A, is not provided with Option 001.

Applications

Option 001 to the HP 16800A and HP 16801A Bar Code Readers provides an excellent solution for both commercial and industrial applications by supporting the popular UPC, EAN, and JAN codes as well as the industry standard 3 of 9 and Interleaved 2 of 5 codes.

Typical applications for UPC, EAN, and JAN codes include:

— Point-of-sale
— Inventory control in retail stores
— Order entry for retail products
— Tracking periodical and/or book returns
— Tracking coupon receipts
— Production line tracking in consumer products manufacturing plants

The 3 of 9 code and Interleaved 2 of 5 code are commonly used for work-in-process tracking and inventory control applications. Some applications may require that the 3 of 9 code or Interleaved 2 of 5 code be read interchangeably with the UPC, EAN, and/or JAN codes. For example, products which are marked with a UPC code may be shipped in a container marked with the Interleaved 2 of 5 code. The automatic code recognition capability of the HP 16800A and HP 16801A allows these codes to be read interchangeably.

Typical applications for 3 of 9 code and Interleaved 2 of 5 code include:

— Inventory control
— Work-in-process tracking
— Distribution tracking
— Records management
— Government packaging and shipping
— Labor reporting
— Asset management

Wand Selection

The HP 16800A and HP 16801A Bar Code Readers include an HBCS-5300 digital bar code wand which is capable of reading bar code symbols which have nominal narrow bar/space widths of 0.19 mm (0.0075 in.) or greater. A 655 nm visible red emitter enables the HBCS-5300 to read a wide variety of colored bar codes. This wand is recommended for reading the UPC, EAN, and JAN bar codes

An optional HBCS-5500 digital bar code wand is available for very high resolution codes having nominal narrow bar/space widths of 0.13 mm (0.005 in.) to 0.20 mm (0.008 in.) An 820 nm near-infrared emitter enables the HBCS-5500 to read black-and-white bar codes and the black-on-black bar codes used in some security systems. It cannot read colored bar codes and, therefore, is not recommended for reading the UPC, EAN, and JAN bar codes.

Applications which require an industrial wand are supported by the optional HBCS-6300 and HBCS-6500 digital bar code wands. These wands feature a solid metal case and internal construction designed for abusive environments. The HBCS-6300 and HBCS-6500 have the same bar code reading characteristics as the HBCS-5300 and HBCS-5500, respectively.

Supporting Literature

For further information, refer to:

16800A/16801A Option 001 Operating and Installation Manual Addendum, P/N: 16800-90004

16800A/16801A Operating and Installation Manual, P/N: 16800-90001

16800A/16801A Data Sheet, Publication No.: 5954-2155

Ordering Information

Product Number	Description
16800A	PROGRAMMABLE BAR CODE READER
-001	Includes HBCS-5300 digital wand, internal power supply for 120 V line voltage, power cord, and Operating and Installation Manuals. Reader supports UPC, EAN, JAN, 3 of 9, and Interleaved 2 of 5 codes.
16801A	NON-PROGRAMMABLE BAR CODE READER
-001	Includes HBCS-5300 digital wand, internal power supply for 120 V line voltage, power cord, and Operating and Installation Manuals. Reader supports UPC, EAN, JAN, 3 of 9, and Interleaved 2 of 5 codes.
-210	100 V power supply
-222	220 V power supply
-224	240 V power supply
-320	Delete HBCS-5300 digital wand; add HBCS-5500 ditigal wand
-400	Delete HBCS-5300 digital wand; add HBCS-6300 industrial digital wand
-420	Delete HBCS-5300 digital wand; add HBCS-6500 industrial digital wand
-610	Add Wall Mounting Kit
-910	Additional Operating and Installation Manuals

Motion Sensing and Control

- **Optical Encoders**
- **Digital Potentiometers**
- **Motion Control ICs**

Motion Sensing and Control

Motion Sensing

As an extension of our emitter/detector systems capability, Hewlett-Packard has developed a family of motion sensing products. These product include optical shaft encoders, optical encoder modules for closed loop servo applications and digital potentiometers for manual input applications. HP's Optical products provide a digital link converting mechanical shaft rotation into TTL logic level signals.

Our HEDS-5000 and HEDS-6000 series encoders may be used in a wide variety of closed loop servo applications varying from computer peripherals and professional audio-video systems to automated production equipment. Encoders also find widespread use in industrial and instrument applications in which digital information is needed to monitor rotary motion.

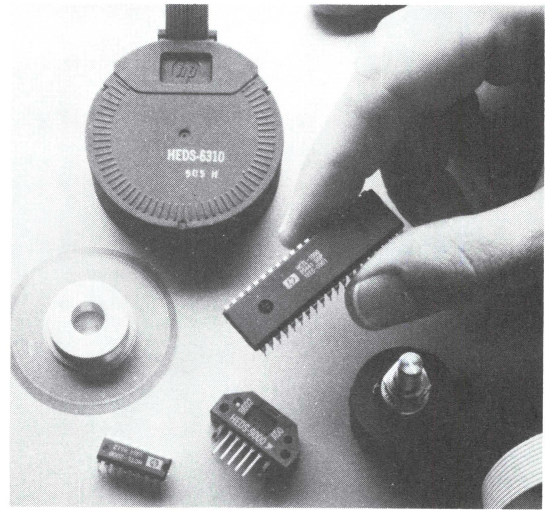
The HP encoder system takes advantage of a specialized optical design and a custom integrated circuit to deliver superior performance in a compact package. The design also minimizes the mechanical tolerances required of the shaft and mounting surface. The HEDS-5000 and HEDS-6000 encoders are available with a range of options including resolution and shaft sizes.

The HEDS-7500 series digital potentiometer is a 28 mm diameter encoder completely assembled with a shaft and bushing, making it suitable for panel mounting. The device converts manual rotary inputs into digital outputs using the same high performance emitter/detector technology used in our encoders. A digital potentiometer can be used as an input mechanism in a variety of applications including: test and measurement equipment, CAD-CAM systems, and positioning tables.

New Products

Hewlett-Packard's new HEDS-9000 and HEDS-9100 series optical encoder modules provide sophisticated rotary motion detection at a low price making it ideal for high volume applications. The modular design approach incorporates a unique photodetector array allowing easy assembly and encoder design flexibility. Standard resolutions for these modules range from 96 to 1000 counts per revolution.

Hewlett-Packard has also introduced the HEDS-9200 series encoder modules which sense linear movement. These encoder modules are based on the same innovative emitter/detector technology as the HEDS-9000 series, however they are optimized to sense linear position. These linear encoder modules are extremely tolerant to misalignment and well suited for printers, copiers, x-y tables and a variety of other industrial and office automation products.



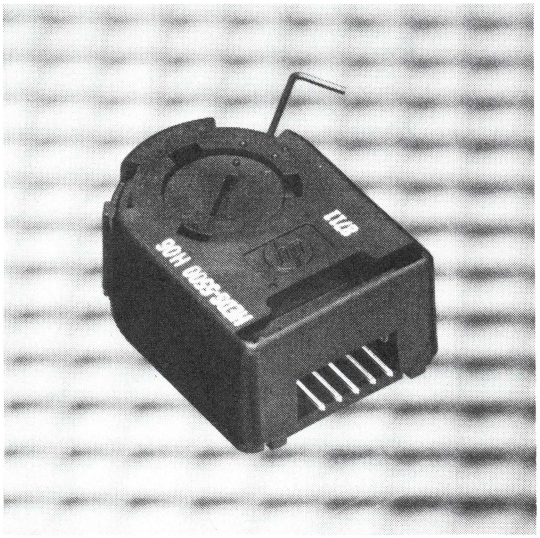
The HEDS-5500 is a quick assembly, low cost, complete optical encoder. This product does not require adhesive, special tools, or any last minute adjustments to complete the assembly process. The encoder features high performance based on the HEDS-9100 series encoder module and comes in a wide variety of resolutions and shaft sizes.

Motion Control

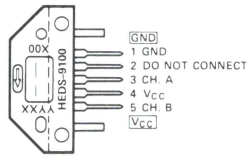
To complement the motion sensing products, HP has released two motion control ICs. The HCTL-1000 general purpose motion control IC greatly simplifies the task of designing digital motion control systems. The HCTL-1000 compares the command position or velocity from a host processor to the actual position or velocity from an incremental encoder, and outputs an appropriate motor command using one of four programmable position and velocity control modes. Some of its other features include a programmable digital filter, an electronic commutator, and a quadrature decoder/counter.

The HCTL-2000 Quadrature Decoder Counter IC provides a one chip, easy to implement solution to interfacing the quadrature output of an encoder or digital potentiometer to a microprocessor. It includes a quadrature decoder, a 12 bit up/down state counter, and an 8 bit bus interface. The use of Schmitt triggered inputs and a digital noise filter allows reliable operation in noisy environments.

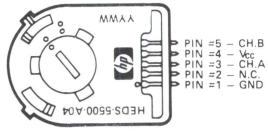
For more information on these new product developments, contact your local Hewlett-Packard Components Field Engineer, or write Hewlett-Packard Optoelectronics Division, 640 Page Mill Road, Palo Alto, California 94304.



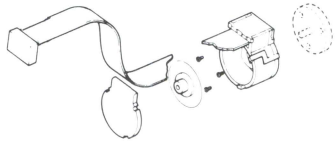
Optical Encoder Modules

Package Outline Drawing	Part No.	Channels	Resolution	Page No.
	HEDS-9000 OPT □ 0 0	A, B	□ A 500 CPR B 1000 CPR	4-7
	HEDS-9100 OPT □ 0 0	A, B	□ K 96 CPR C 100 CPR D 192 CPR E 200 CPR F 256 CPR G 360 CPR H 400 CPR A 500 CPR I 512 CPR	4-11
	HEDS-9200 OPT □ 0 0	A, B	□ L 120 LPI M 127 LPI P 150 LPI	4-15

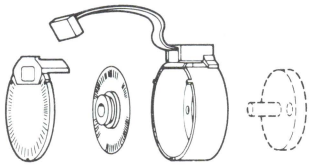
Quick Assembly Encoder — HEDS-5500 Series

Package Outline Drawing	Part No.	Channels	Option Code		Page No.
			Resolution	Shaft Size	
	HEDS-5500 OPT □ □□	A, B	□ K 96 CPR C 100 CPR D 192 CPR E 200 CPR F 256 CPR G 360 CPR H 400 CPR A 500 CPR I 512 CPR	□□ 01 2 mm 02 3 mm 03 1/8 in. 04 5/32 in. 05 3/16 in. 06 1/4 in. 11 4 mm 12 6 mm 14 5 mm	4-19

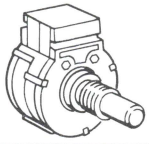
28 mm Diameter Encoders — HEDS-5000 Series

Package Outline Drawing	Part No.	Channels	Option Code		Page No.
			Resolution	Shaft Size	
	HEDS-5000 OPT □ □□	A, B	□ C 100 CPR D 192 CPR E 200 CPR F 256 CPR G 360 CPR H 400 CPR A 500 CPR I 512 CPR	□□ 01 2 mm 02 3 mm 03 1/8 in. 04 5/32 in. 05 3/16 in. 06 1/4 in. 11 4 mm 14 5 mm	4-25
	HEDS-5010 OPT □ □□	A, B, I			

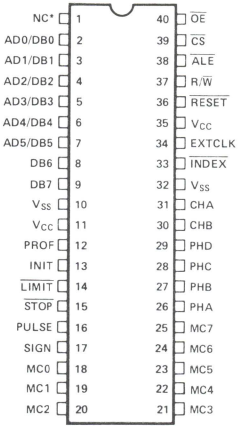
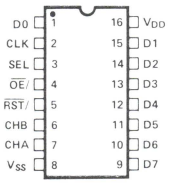
56 mm Diameter Encoders — HEDS-6000 Series

Package Outline Drawing	Part No.	Channels	Option Code		Page No.
			Resolution	Shaft Size	
	HEDS-6000 OPT □ □□	A, B	□ E 200 CPR H 400 CPR A 500 CPR I 512 CPR B 1000 CPR J 1024 CPR	□□ 05 3/16 in. 06 1/4 in. 07 5/16 in. 08 3/8 in. 09 1/2 in. 10 5/8 in. 11 4 mm 12 6 mm 13 8 mm	4-33
	HEDS-6010 OPT □ □□	A, B, I			

Digital Potentiometer — HEDS-7500 Series

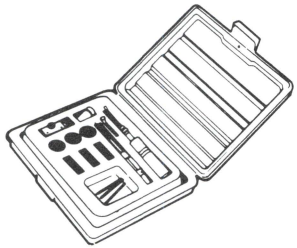
Package Outline Drawing	Part No.	Resolution	Termination	Page No.
	HEDS-7500	256 CPR	Color Coded Wire	4-41
	HEDS-7501	256 CPR	Ribbon Cable	

Motion Control ICs — HCTL-XXXX Series

Package Outline	Part No.	Description	Page No.
 * SHOULD BE LEFT FLOATING.	HCTL-1000	General Purpose Motion Control IC	4-43
	HCTL-2000	Quadrature Decoder/Counter IC	4-67

MOTION SENSING AND CONTROL

Convenience Assembly Tools for 28 mm Diameter Encoders — Not Required

Package Outline Drawing	Part No.	Description	Page No.
	HEDS-8930	HEDS-5000 Series Tool Kit • Holding Screwdriver • Torque Limiting Screwdriver • HEDS-8920 Hub Puller • HEDS-8922 Gap Setter	4-25
	HEDS-892X	Centering Cones • Aid in High Volume Assembly • Order in Appropriate Shaft Size	

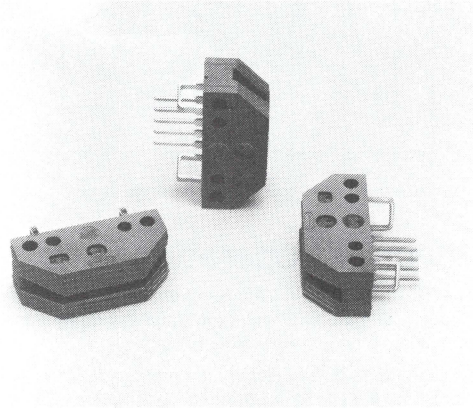
HEWLETT PACKARD

TWO CHANNEL OPTICAL INCREMENTAL ENCODER MODULE

HEDS-9000 SERIES

Features

- HIGH PERFORMANCE
- HIGH RESOLUTION
- LOW COST
- EASY TO MOUNT
- NO SIGNAL ADJUSTMENT REQUIRED
- INSENSITIVE TO RADIAL AND AXIAL PLAY
- SMALL SIZE
- –40° C to 100° C OPERATING TEMPERATURE
- TWO CHANNEL QUADRATURE OUTPUT
- TTL COMPATIBLE
- SINGLE 5 V SUPPLY



Description

The HEDS-9000 series is a high performance, low cost, optical incremental encoder module. When operated in conjunction with a codewheel, this module detects rotary position. The module consists of a lensed LED source and a detector IC enclosed in a small C-shaped plastic package. Due to a highly collimated light source and a unique photodetector array, the module is extremely tolerant to mounting misalignment.

The two channel digital outputs and the single 5 V supply input are accessed through four 0.025 inch square pins located on 0.1 inch centers.

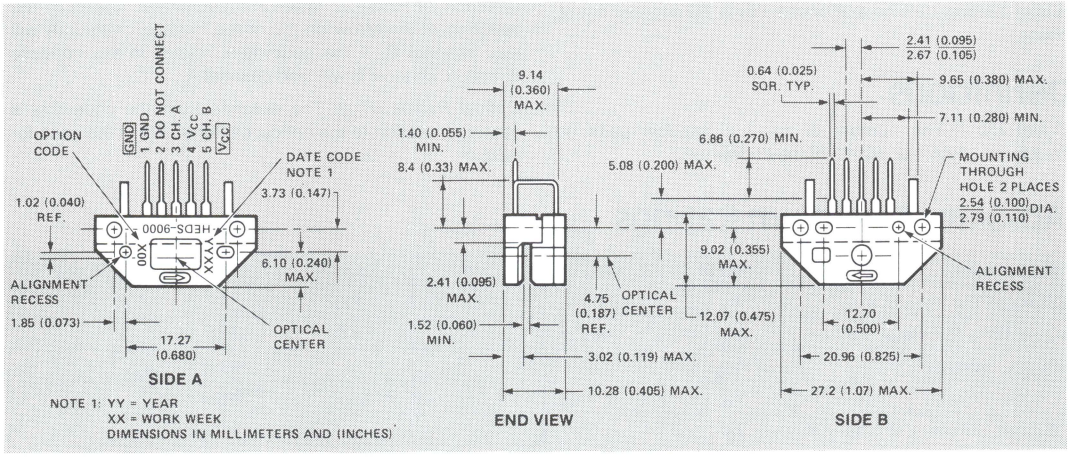
The standard resolutions presently available are 500 CPR and 1000 CPR for use with a HEDS-6100 series codewheel or the equivalent. Consult local Hewlett-Packard sales representatives for custom resolutions.

Applications

The HEDS-9000 provides sophisticated motion detection at a low cost, making it ideal for high volume applications. Typical applications include printers, plotters, tape drives, and factory automation equipment.

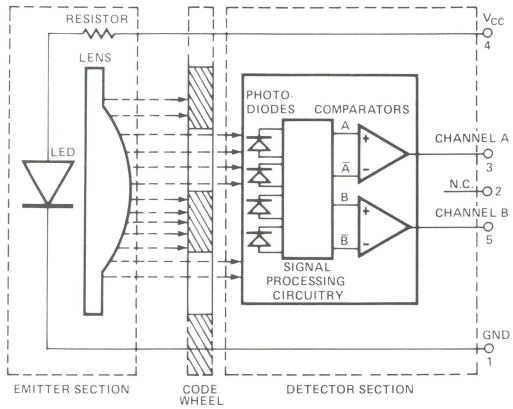
ESD WARNING: NORMAL HANDLING PRECAUTIONS SHOULD BE TAKEN TO AVOID STATIC DISCHARGE.

Package Dimensions

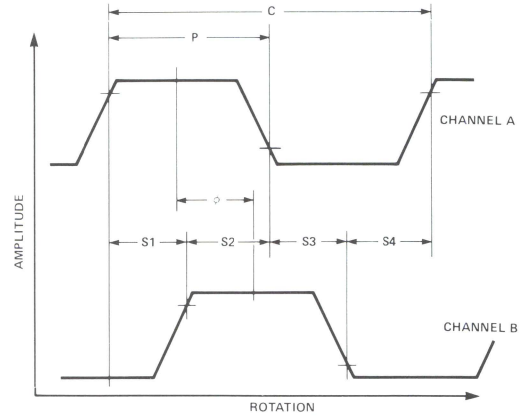


MOTION SENSING AND CONTROL

Block Diagram



Output Waveforms



Theory of Operation

The HEDS-9000 is a C-shaped emitter/detector module. Coupled with a codewheel it translates the rotary motion of a shaft into a two-channel digital output.

As seen in the block diagram, the module contains a single Light Emitting Diode (LED) as its light source. The light is collimated into a parallel beam by means of a single lens located directly over the LED. Opposite the emitter is the integrated detector circuit. This IC consists of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The codewheel rotates between the emitter and detector, causing the light beam to be interrupted by the pattern of spaces and bars on the codewheel. The photodiodes which detect these interruptions are arranged in a pattern that corresponds to the radius and design of the codewheel. These detectors are also spaced such that a light period on one pair of detectors corresponds to a dark period on the adjacent pair of detectors. The photodiode outputs are then fed through the signal processing circuitry resulting in A, $\overline{A}$, B and $\overline{B}$. Two comparators receive these signals and produce the final outputs for channels A and B. Due to this integrated phasing technique, the digital output of channel A is in quadrature with that of channel B (90 degrees out of phase).

Definitions

Count (N) = The number of bar and window pairs or counts per revolution (CPR) of the codewheel.

1 Shaft Rotation = 360 mechanical degrees
= N cycles

1 cycle (c) = 360 electrical degrees (°e)
= 1 bar and window pair

Pulse Width (P): The number of electrical degrees that an output is high during 1 cycle. This value is nominally 180 °e or ½ cycle.

Pulse Width Error (ΔP): The deviation, in electrical degrees, of the pulse width from its ideal value of 180 °e.

State Width (S): The number of electrical degrees between a transition in the output of channel A and the neighboring transition in the output of channel B. There are 4 states per cycle, each nominally 90 °e.

State Width Error (ΔS): The deviation, in electrical degrees, of each state width from its ideal value of 90°e.

Phase (ϕ): The number of electrical degrees between the center of the high state of channel A and the center of the high state of channel B. This value is nominally 90 °e for quadrature output.

Phase Error ($\Delta\phi$): The deviation of the phase from its ideal value of 90 °e.

Direction of Rotation: When the codewheel rotates in the direction of the arrow on top of the module, channel A will lead channel B. If the codewheel rotates in the opposite direction, channel B will lead channel A.

Optical Radius (R_{op}): The distance from the codewheel's center of rotation to the optical center (O.C.) of the encoder module.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Storage Temperature	T_S	-40		100	°C	
Operating Temperature	T_a	-40		100	°C	
Supply Voltage	V_{CC}	-0.5		7	Volts	
Output Voltage	V_O	-0.5		V_{CC}	Volts	
Output Current per Channel	I_O	-1.0		5	mA	

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Temperature	T	-40		100	°C	
Supply Voltage	V_{CC}	4.5		5.5	Volts	Ripple <100mVp-p
Load Capacitance	C_L			100	pF	3.2 KΩ pull-up resistor
Count Frequency	f			100	kHZ	$\frac{\text{Velocity(rpm)xN}}{60}$

Note: The module performance is guaranteed to 100 kHZ but can operate at higher frequencies.

Encoding Characteristics

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances. These characteristics do not include codewheel contributions.

Parameter	Symbol	Typ.	Case 1 Max.	Case 2 Max.	Units	Notes
Pulse Width Error	Δp	7	30	40	elec. deg	
Logic State Width Error	Δs	5	30	40	elec. deg.	
Phase Error	$\Delta\phi$	2	10	15	elec deg.	

Case 1: Module mounted on tolerances of ±.13mm(.005"). Case 2: Module mounted on tolerances of ±.50mm(.020")

Electrical Characteristics

Electrical Characteristics over Recommended Operating Range, typical at 25° C

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}		17	40	mA	
High Level Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -40 μA Max.
Low Level Output Voltage	V_{OL}			0.4	Volts	I_{OL} = 3.2 mA
Rise Time	t_r		200		ns	C_L = 25 pF
Fall Time	t_f		50		ns	R_L = 11 KΩ pull-up

Note:
1. For improved performance in noisy environments or high speed applications, a 3.3 kΩ pull-up resistor is recommended.

Recommended Codewheel Characteristics

The HEDS-9000 is designed to operate with the HEDS-6100 series codewheel. See ordering information and specifications at the end of this data sheet.

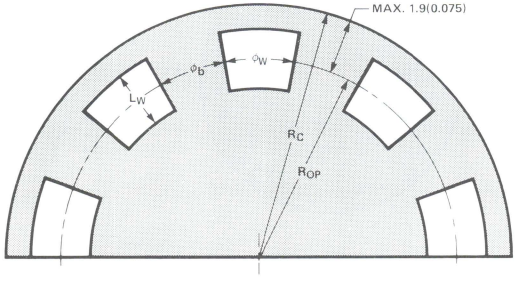


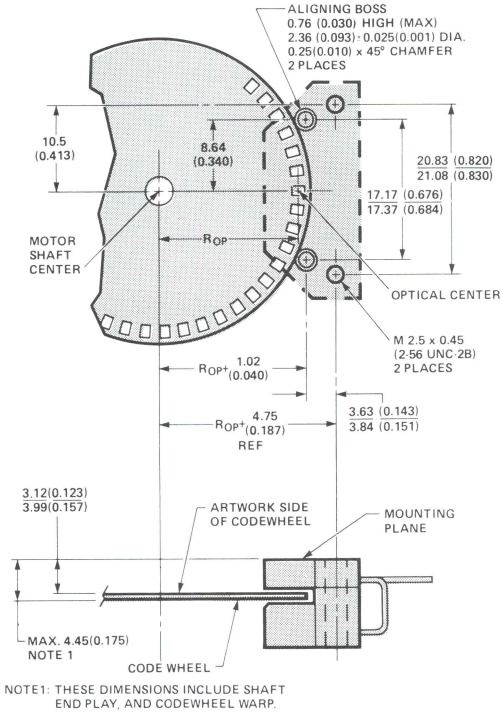
Figure 1. Codewheel Design

Codewheel Options

CPR (N)	OPTICAL RADIUS R_{op} mm (inch)
500	23.36 (.920)
1000	23.36 (.920)

Parameter	Symbol	Min.	Max.	Units	Notes
Window/Bar Ratio	ϕ_W/ϕ_b	0.7	1.4		
Window Length	L_W	1.8(.07)	2.3(.09)	mm(inch)	
Absolute Maximum Codewheel Radius	R_C		R_{op}+1.9(0.075)	mm(inch)	Includes eccentricity errors

Mounting Considerations



NOTE1: THESE DIMENSIONS INCLUDE SHAFT END PLAY, AND CODEWHEEL WARP.

Figure 2. Mounting Plane Side A.

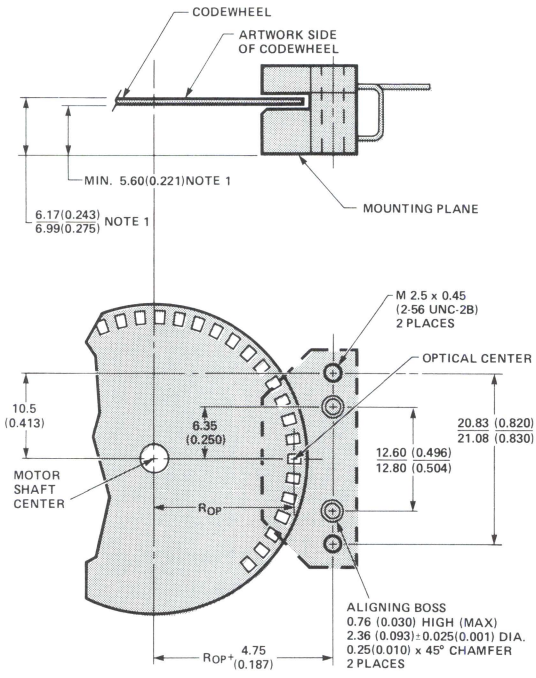


Figure 3. Mounting Plane Side B.

Connectors

Manufacturer	Part Number	Mounting Surface
AMP	103686-4	Both
	640442-5	Side B
Berg	65039-032 with 4825X-000 terminals	Both
Molex	2695 series with 2759 series terminals	Side B

Figure 4. Connector Specifications

Ordering Information

HEDS-9000 Option ☐ 0 0

HEDS-6100 Option ☐ ☐☐

Resolution (Cycles per Revolution)
A — 500 cpr
B — 1000 cpr

Shaft Diameter	
05 — 3/16 IN.	11 — 4 mm
06 — 1/4 IN.	12 — 6 mm
07 — 5/16 IN.	13 — 8 mm
08 — 3/8 IN.	
09 — 1/2 IN.	
10 — 5/8 IN.	

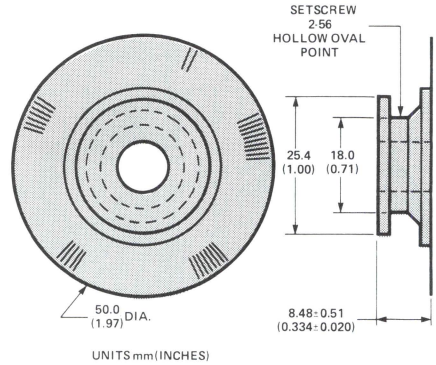


Figure 5. HEDS-6100 Codewheel

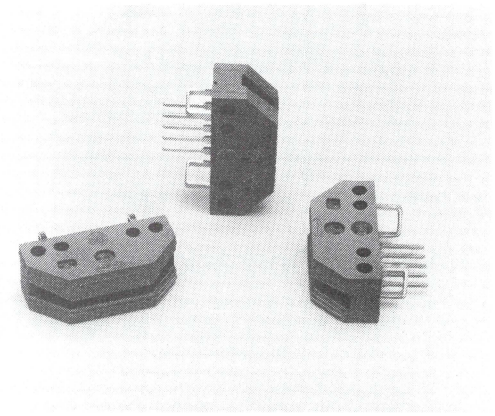
HEWLETT PACKARD

TWO CHANNEL OPTICAL INCREMENTAL ENCODER MODULE 11 mm Optical Radius

HEDS-9100 SERIES

Features

- HIGH PERFORMANCE
- HIGH RESOLUTION
- LOW COST
- EASY TO MOUNT
- NO SIGNAL ADJUSTMENT REQUIRED
- INSENSITIVE TO RADIAL AND AXIAL PLAY
- SMALL SIZE
- –40° C to 100° C OPERATING TEMPERATURE
- TWO CHANNEL QUADRATURE OUTPUT
- TTL COMPATIBLE
- SINGLE 5 V SUPPLY



Description

The HEDS-9100 series is a high performance, low cost, optical incremental encoder module. When operated in conjunction with a codewheel, this module detects rotary position. The module consists of a lensed LED source and a detector IC enclosed in a small C-shaped plastic package. Due to a highly collimated light source and a unique photodetector array, the module is extremely tolerant to mounting misalignment.

The two channel digital outputs and the single 5 V supply input are accessed through four 0.025 inch square pins located on 0.1 inch centers.

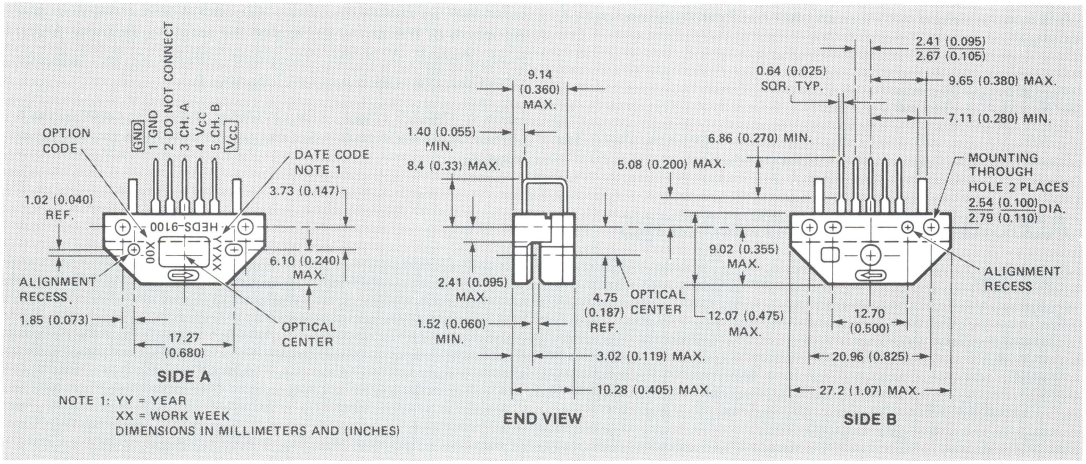
The standard resolutions presently available range from 96 cpr to 512 cpr for use with a HEDS-5100 series codewheel or the equivalent. Consult local Hewlett-Packard sales representatives for custom resolutions.

Applications

The HEDS-9100 provides sophisticated motion detection at a low cost, making it ideal for high volume applications. Typical applications include printers, plotters, tape drives, and factory automation equipment.

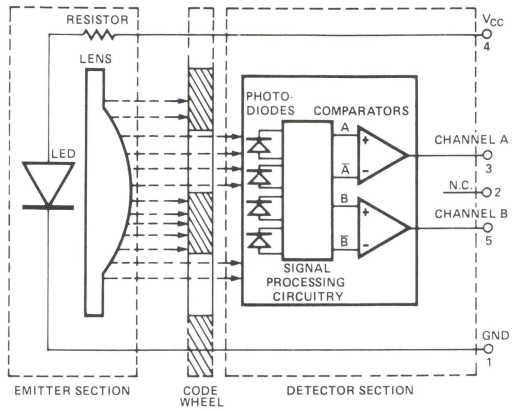
ESD WARNING: NORMAL HANDLING PRECAUTIONS SHOULD BE TAKEN TO AVOID STATIC DISCHARGE.

Package Dimensions

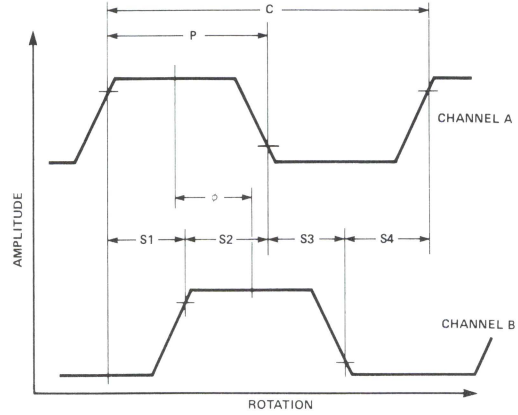


MOTION SENSING AND CONTROL

Block Diagram



Output Waveforms



Theory of Operation

The HEDS-9100 is a C-shaped emitter/detector module. Coupled with a codewheel it translates the rotary motion of a shaft into a two-channel digital output.

As seen in the block diagram, the module contains a single Light Emitting Diode (LED) as its light source. The light is collimated into a parallel beam by means of a single lens located directly over the LED. Opposite the emitter is the integrated detector circuit. This IC consists of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The codewheel rotates between the emitter and detector, causing the light beam to be interrupted by the pattern of spaces and bars on the codewheel. The photodiodes which detect these interruptions are arranged in a pattern that corresponds to the radius and design of the codewheel. These detectors are also spaced such that a light period on one pair of detectors corresponds to a dark period on the adjacent pair of detectors. The photodiode outputs are then fed through the signal processing circuitry resulting in A, $\overline{A}$, B and $\overline{B}$. Two comparators receive these signals and produce the final outputs for channels A and B. Due to this integrated phasing technique, the digital output of channel A is in quadrature with that of channel B (90 degrees out of phase).

Definitions

Count (N) = The number of bar and window pairs or counts per revolution (CPR) of the codewheel.

1 Shaft Rotation = 360 mechanical degrees
= N cycles

1 cycle (c) = 360 electrical degrees (°e)
= 1 bar and window pair

Pulse Width (P): The number of electrical degrees that an output is high during 1 cycle. This value is nominally 180 °e or ½ cycle.

Pulse Width Error (ΔP): The deviation, in electrical degrees, of the pulse width from its ideal value of 180 °e.

State Width (S): The number of electrical degrees between a transition in the output of channel A and the neighboring transition in the output of channel B. There are 4 states per cycle, each nominally 90 °e.

State Width Error (ΔS): The deviation, in electrical degrees, of each state width from its ideal value of 90°e.

Phase (ϕ): The number of electrical degrees between the center of the high state of channel A and the center of the high state of channel B. This value is nominally 90 °e for quadrature output.

Phase Error ($\Delta\phi$): The deviation of the phase from its ideal value of 90 °e.

Direction of Rotation: When the codewheel rotates in the direction of the arrow on top of the module, channel A will lead channel B. If the codewheel rotates in the opposite direction, channel B will lead channel A.

Optical Radius (R_{op}): The distance from the codewheel's center of rotation to the optical center (O.C.) of the encoder module.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Storage Temperature	T_S	-40		100	°C	
Operating Temperature	T_a	-40		100	°C	
Supply Voltage	V_{CC}	-0.5		7	Volts	
Output Voltage	V_O	-0.5		V_{CC}	Volts	
Output Current per Channel	I_O	-1.0		5	mA	

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Temperature	T	-40		100	°C	
Supply Voltage	V_{CC}	4.5		5.5	Volts	Ripple <100mVp-p
Load Capacitance	C_L			100	pF	3.2 KΩ pull-up resistor
Count Frequency	f			100	kHZ	$\frac{\text{Velocity(rpm)xN}}{60}$

Note: The module performance is guaranteed to 100 kHZ but can operate at higher frequencies.

Encoding Characteristics

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances. These characteristics do not include codewheel contributions.

Parameter	Symbol	Typ.	Case 1 Max.	Case 2 Max.	Units	Notes
Pulse Width Error	Δp	7	30	40	elec. deg	
Logic State Width Error	Δs	5	30	40	elec. deg.	
Phase Error	$\Delta\phi$	2	10	15	elec deg.	

Case 1: Module mounted on tolerances of ±0.13mm(0.005").

Case 2: Module mounted on tolerances of ±0.38mm(0.015").

Electrical Characteristics

Electrical Characteristics over Recommended Operating Range, typical at 25° C

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}		17	40	mA	
High Level Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -40 μA Max.
Low Level Output Voltage	V_{OL}			0.4	Volts	I_{OL} = 3.2 mA
Rise Time	t_r		200		ns	C_L = 25 pF
Fall Time	t_f		50		ns	R_L = 11 KΩ pull-up

Note:

1. For improved performance in noisy environments or high speed applications, a 3.3 kΩ pull-up resistor is recommended.

Recommended Codewheel Characteristics

The HEDS-9100 is designed to operate with the HEDS-5100 series codewheel. See ordering information and specifications at the end of this data sheet.

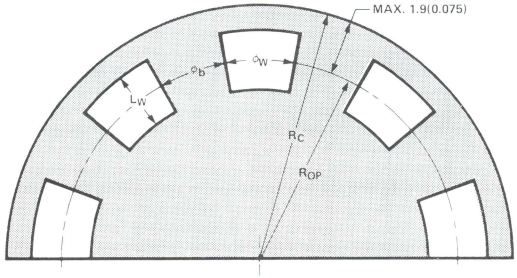


Figure 1. Codewheel Design

Parameter	Symbol	Min.	Max.	Units	Notes
Window/Bar Ratio	ϕ_W/ϕ_b	0.7	1.4		
Window Length	L_W	1.8(.07)	2.3(.09)	mm(inch)	
Absolute Maximum Codewheel Radius	R_C		R_{OP}+1.9(0.075)	mm(inch)	Includes eccentricity errors

Codewheel Options

CPR (N)	OPTICAL RADIUS R_{OP} mm (inch)
96	11.00 (0.433)
100	11.00 (0.433)
192	11.00 (0.433)
200	11.00 (0.433)
256	11.00 (0.433)
360	11.00 (0.433)
400	11.00 (0.433)
500	11.00 (0.433)
512	11.00 (0.433)

Mounting Considerations

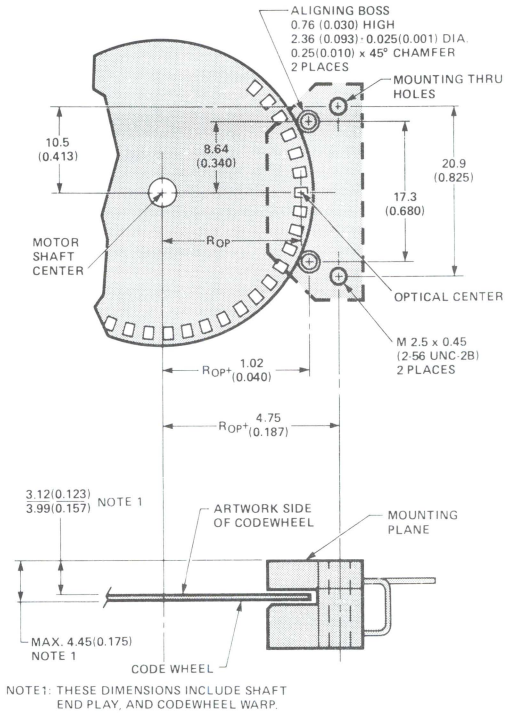


Figure 2. Mounting Plane Side A.

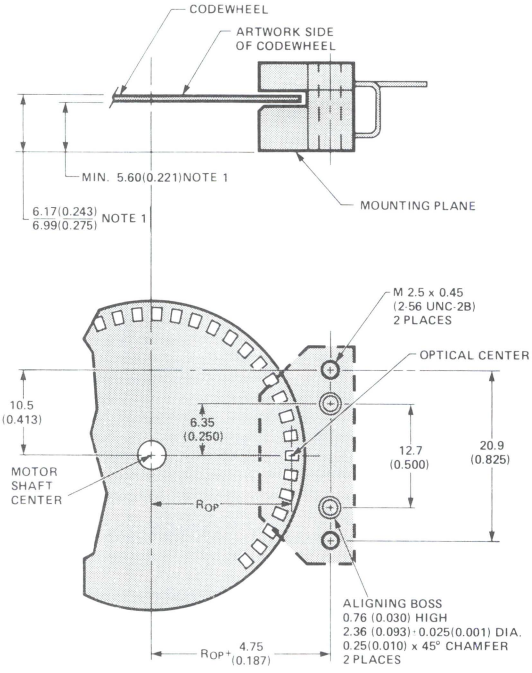


Figure 3. Mounting Plane Side B.

Connectors

Manufacturer	Part Number	Mounting Surface
AMP	103686-4	Both
	640442-5	Side B
Berg	65039-032 with 4825X-000 terminals	Both
Molex	2695 series with 2759 series terminals	Side B

Figure 4. Connector Specifications

Ordering Information

HEDS-9100 Option ☐ 0 0

HEDS-5100 Option ☐ ☐

Resolution (Cycles per Revolution)	
K - 96 cpr	G - 360 cpr
C - 100 cpr	H - 400 cpr
D - 192 cpr	A - 500 cpr
E - 200 cpr	I - 512 cpr
F - 256 cpr	

Shaft Diameter	
01 — 2 mm	11 — 4 mm
02 — 3 mm	14 — 5 mm
03 — 1/8 in.	12 — 6 mm
04 — 5/32 in.	
05 — 3/16 in.	
06 — 1/4 in.	

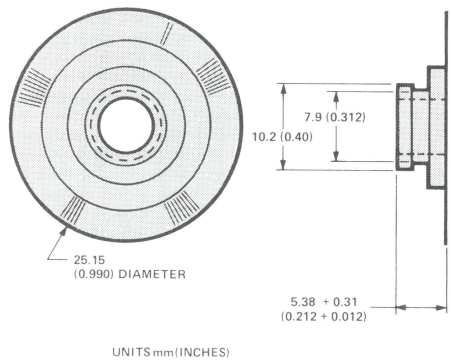


Figure 5. HEDS-5100 Codewheel

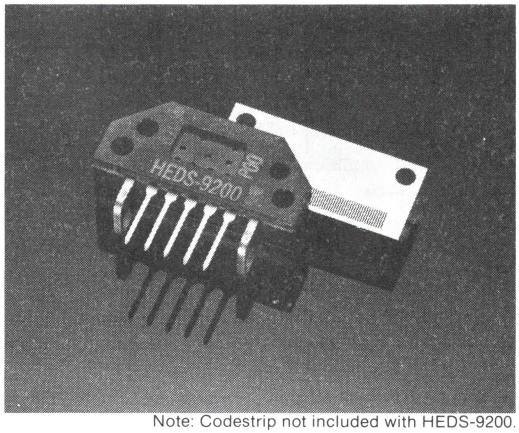
HEWLETT PACKARD

LINEAR OPTICAL INCREMENTAL ENCODER MODULE

HEDS-9200 SERIES

Features

- HIGH PERFORMANCE
- HIGH RESOLUTION
- LOW COST
- EASY TO MOUNT
- NO SIGNAL ADJUSTMENT REQUIRED
- INSENSITIVE TO MECHANICAL DISTURBANCES
- SMALL SIZE
- -40° C TO 100° C OPERATING TEMPERATURE
- TWO CHANNEL QUADRATURE OUTPUT
- TTL COMPATIBLE
- SINGLE 5 V SUPPLY



Note: Codestrip not included with HEDS-9200.

Description

The HEDS-9200 series is a high performance, low cost, optical incremental encoder module. When operated in conjunction with a codestrip, this module detects linear position. The module consists of a lensed LED source and a detector IC enclosed in a small C-shaped plastic package. Due to a highly collimated light source and a unique photodetector array, the module is extremely tolerant to mounting misalignment.

The two channel digital outputs and the single 5 V supply input are accessed through four 0.025 inch square pins located on 0.1 inch centers.

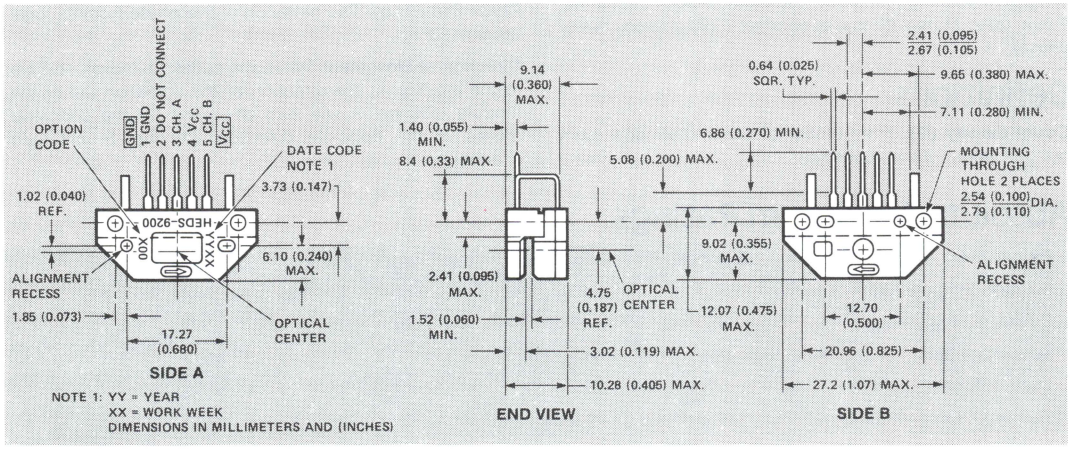
The standard resolutions available are 4.72 counts per mm (120 cpi), 5.00 counts per mm (127 cpi) and 5.91 counts per mm (150 cpi). Consult local Hewlett-Packard sales representatives for other resolutions ranging from 1.5 to 7.8 counts per mm (40 to 200 counts per inch).

Applications

The HEDS-9200 provides sophisticated motion detection at a low cost, making it ideal for high volume applications. Typical applications include printers, plotters, tape drives, and factory automation equipment.

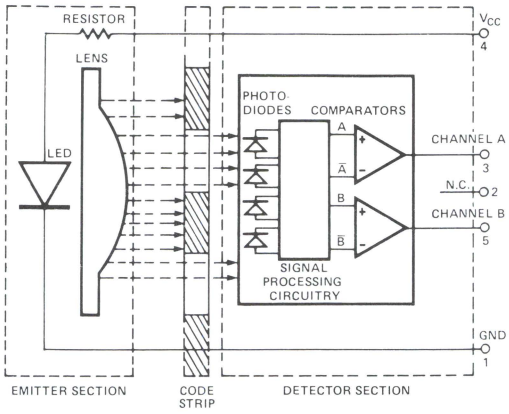
ESD WARNING: NORMAL HANDLING PRECAUTIONS SHOULD BE TAKEN TO AVOID STATIC DISCHARGE.

Package Dimensions

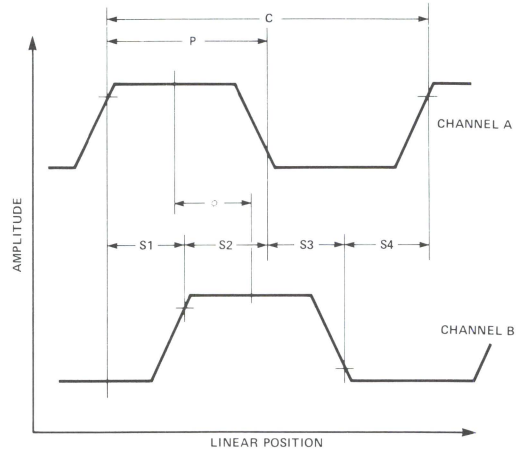


MOTION SENSING AND CONTROL

Block Diagram



Output Waveforms



Theory of Operation

The HEDS-9200 is a C-shaped emitter/detector module. Coupled with a codestrip it translates linear motion into a two-channel digital output.

As seen in the block diagram, the module contains a single Light Emitting Diode (LED) as its light source. The light is collimated into a parallel beam by means of a single lens located directly over the LED. Opposite the emitter is the integrated detector circuit. This IC consists of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The codestrip moves between the emitter and detector, causing the light beam to be interrupted by the pattern of spaces and bars on the codestrip. The photodiodes which detect these interruptions are arranged in a pattern that corresponds to the count density of the codestrip. These detectors are also spaced such that a light period on one pair of detectors corresponds to a dark period on the adjacent pair of detectors. The photodiode outputs are then fed through the signal processing circuitry resulting in A, $\overline{A}$, B and $\overline{B}$. Two comparators receive these signals and produce the final outputs for channels A and B. Due to this integrated phasing technique, the digital output of channel A is in quadrature with that of channel B (90 degrees out of phase).

Definitions

Count density (D): The number of bar and window pairs per unit length of the codestrip.

Pitch: 1/D, The unit length per count.

Electrical degree (°e): Pitch/360, The dimension of one bar and window pair divided by 360.

1 cycle (C): 360 electrical degrees, 1 bar and window pair.

Pulse Width (P): The number of electrical degrees that an output is high during 1 cycle. This value is nominally 180°e or 1/2 cycle.

Pulse Width Error (ΔP): The deviation, in electrical degrees, of the pulse width from its ideal value of 180°e.

State Width(S): The number of electrical degrees between a transition in the output of channel A and the neighboring transition in the output of channel B. There are 4 states per cycle, each nominally 90°e.

State Width Error (ΔS): The deviation, in electrical degrees, of each state width from its ideal value of 90°e.

Phase (ϕ): The number of electrical degrees between the center of the high state of channel A and the center of the high state of channel B. This value is nominally 90°e for quadrature output.

Phase Error ($\Delta\phi$): The deviation of the phase from its ideal value of 90°e.

Direction of Movement: When the codestrip moves, relative to the module, in the direction of the arrow on top of the module, channel A will lead channel B. If the codestrip moves in the opposite direction, channel B will lead channel A.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Storage Temperature	T_S	-40		100	°C	
Operating Temperature	T_S	-40		100	°C	
Supply Voltage	V_{CC}	-0.5		7	Volts	
Output Voltage	V_O	-0.6		V_{CC}	Volts	
Output Current per Channel	I_O	-1.0		5	mA	

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Temperature	T	-40		100	°C	
Supply Voltage	V_{CC}	4.5		5.5	Volts	Ripple < 100 m Vp-p
Load Capacitance	C_L			100	pF	3.2 KΩ pull-up resistor
Count Frequency	f			100	kHz	Velocity X D

Note:
The module performance is guaranteed to 100 kHz but can operate at higher frequencies.

Encoding Characteristics

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances. These characteristics do not include codestrip defects.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Pulse Width Error	ΔP		7	35	elec. deg.	
Logic State Width Error	ΔS		5	35	elec. deg.	
Phase Error	$\Delta\phi$		2	13	elec. deg.	

Electrical Characteristics

Electrical Characteristics over Recommended Operating Range, typical at 25° C

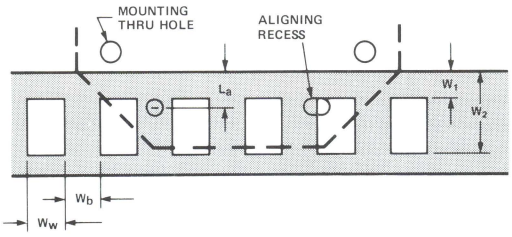
Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}		17	40	mA	
High Level Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -40 μA Max.
Low Level Output Voltage	V_{OL}			0.4	Volts	I_{OL} = 3.2 mA
Rise Time	t_r		200		ns	C_L = 25 pF
Fall Time	t_f		50		ns	R_L = 11 KΩ pull-up

Note:
1. For improved performance in noisy environments or high speed applications, a 3.3 kΩ pull-up resistor is recommended.

Recommended Codestrip Characteristics

Codestrip design must take into consideration mounting as referenced to either side A *or* side B (See figure 1).

MOUNTING AS REFERENCED TO SIDE A



MOUNTING AS REFERENCED TO SIDE B

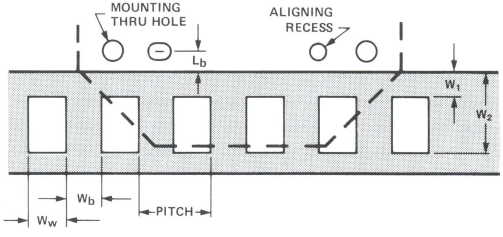
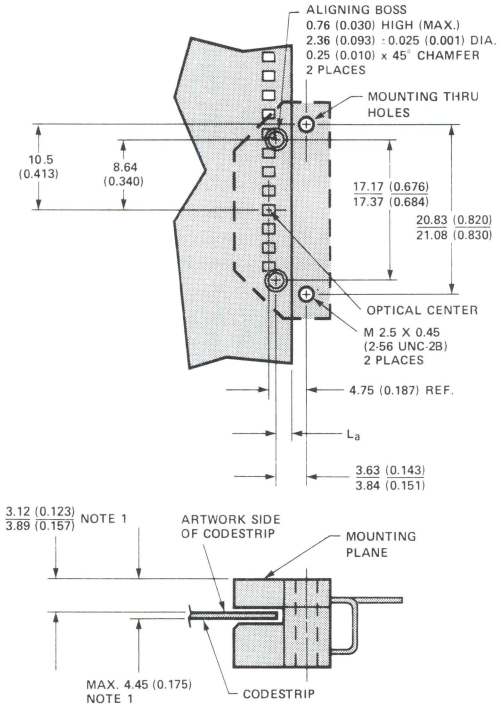


Figure 1. Codestrip Design

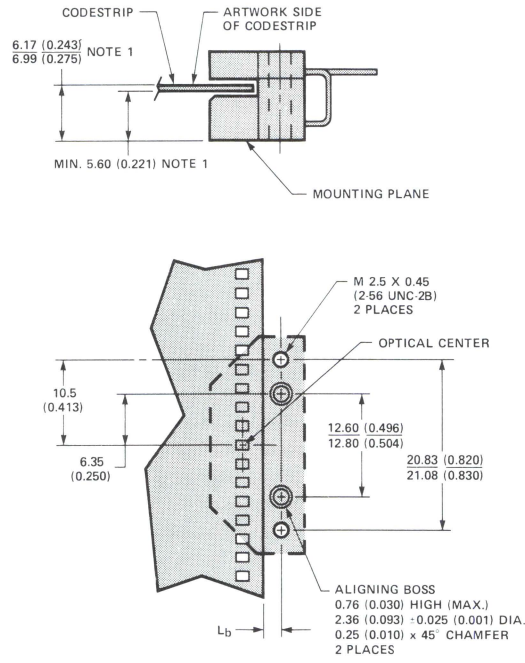
Parameter	Symbol	Mounting Ref. Side A	Mounting Ref. Side B	Units
Window/Bar Ratio	W_w/W_b	0.7 Min. 1.4 Max.	0.7 Min. 1.4 Max.	
Mounting Distance	L	$L_a \leq 0.51$ (0.020)	$L_b \geq 3.23$ (0.127)	mm (inch)
Codestrip edge to inside window edge	W_1	$W_1 \leq 0.53$ (0.021) + L_a	$W_1 \leq 4.27$ (0.168) - L_b	mm (inch)
Codestrip edge to outside window edge	W_2	$W_2 \geq 1.50$ (0.059) + L_a	$W_2 \geq 5.23$ (0.206) - L_b	mm (inch)

Note:
All parameters and equations must be satisfied over the full length of codestrip travel including maximum codestrip runout.

Mounting Considerations



MOUNTING PLANE SIDE A



MOUNTING PLANE SIDE B

Notes:
1. These dimensions inlcude codestrip warp.
2. Reference definitions of L_a and L_b on page 3.

Connectors

Manufacturer	Part Number	Mounting Surface
AMP	103686-4	Both
	640442-5	Side B
Berg	65039-032 with 4825X-000 terminals	Both
Molex	2695 series with 2759 series terminals	Side B

Figure 4. Connector Specifications

Ordering Information

HEDS-9200 Option [ ] [0] [0]

RESOLUTION Counts per mm (inch)	PITCH mm (inch) per count
L — 4.72 (120)	0.212 (0.0083)
M — 5.00 (127)	0.200 (0.0079)
P — 5.91 (150)	0.169 (0.0067)

Consult local Hewlett-Packard sales representatives for other resolutions.

HEWLETT PACKARD

QUICK ASSEMBLY OPTICAL ENCODER

HEDS-5500 SERIES

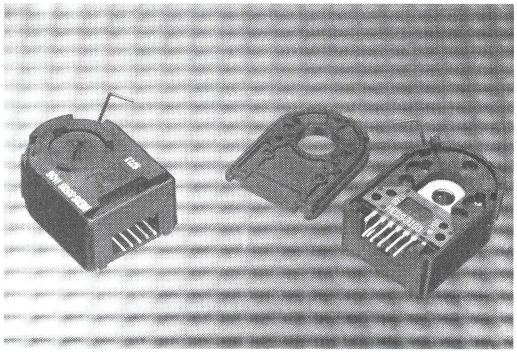
Features

- QUICK AND EASY ASSEMBLY
- NO SIGNAL ADJUSTMENT REQUIRED
- LOW COST
- SMALL SIZE
- HIGH PERFORMANCE
- HIGH RESOLUTION
- INSENSITIVE TO RADIAL AND AXIAL PLAY
- -40° C TO 100° C OPERATING TEMPERATURE
- TWO CHANNEL QUADRATURE OUTPUT
- TTL COMPATIBLE OUTPUTS
- SINGLE 5 V SUPPLY

Description

The HEDS-5500 is a high performance, low cost, optical incremental encoder which emphasizes high reliability, high resolution and easy assembly.

The encoder contains a lensed LED light source, an integrated circuit with detectors and output circuitry, and a code wheel which rotates between the emitter and detector IC. The outputs of the encoder are two square waves in quadrature. The collimated light and special photodetector configuration allow for high resolution and excellent encoding performance as well as increased long life reliability.



The encoder may be quickly and easily mounted onto a motor. No mechanical or electrical adjustments are required.

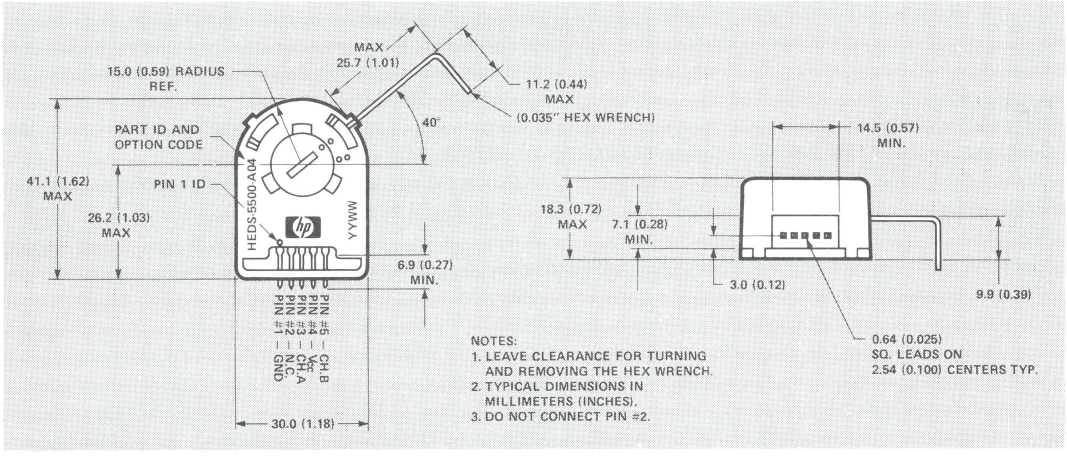
The two channel digital outputs and the single 5 V supply input are accessed through 0.025 inch square pins located on 0.1 inch centers.

Applications

The HEDS-5500 provides motion detection at a low cost, making it ideal for high volume applications. Typical applications include printers, plotters, tape drives, positioning tables and automatic handlers.

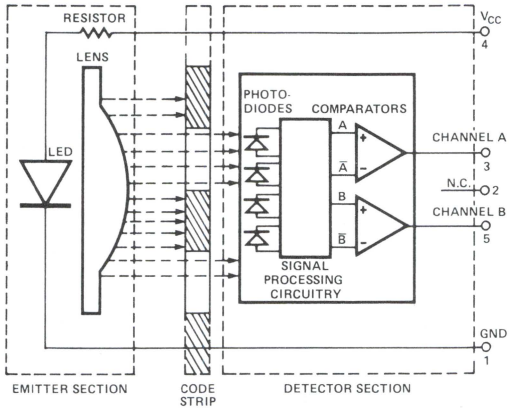
ESD WARNING: NORMAL HANDLING PRECAUTIONS SHOULD BE TAKEN TO AVOID STATIC DISCHARGE.

Outline Drawing

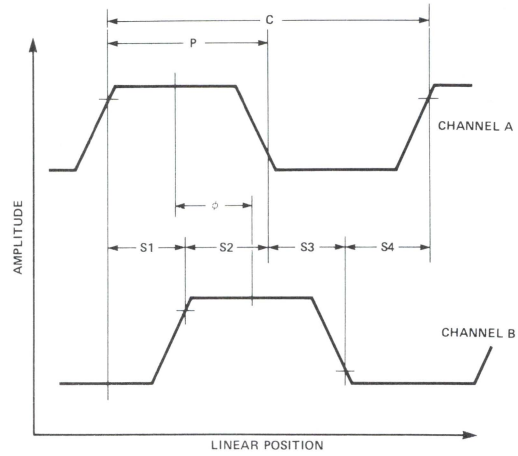


MOTION SENSING AND CONTROL

Block Diagram



Output Waveforms



Theory of Operation

The HEDS-5500 translates rotary motion of a shaft into a two channel digital quadrature output.

As seen in the block diagram, the HEDS-5500 encoder contains a single Light Emitting Diode (LED) as its emitter. The light is collimated into a parallel beam by means of a single lens located directly over the LED. Opposite the emitter is an integrated detector circuit. This IC consists of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The code wheel rotates between the emitter and detector, causing the light beam to be interrupted by the code wheel's pattern of spaces and bars. The photodiodes which detect these interruptions are arranged in a pattern that corresponds to the radius and design of the code wheel. These detectors are also spaced such that a light period on one pair of detectors corresponds to a dark period on the adjacent pair of detectors. The photodiode outputs are then fed through the signal processing circuitry resulting in A, $\overline{A}$, B and $\overline{B}$. Two comparators receive these signals and produce the final outputs for channels A and B. Due to this integrated phasing technique, the digital output of channel A is in quadrature with that of channel B (90 degrees out of phase).

Definitions

Count (N): The number of bar and window pairs or counts per revolution (CPR) of the code wheel.

Electrical Degree (° e): The dimension of one bar and window pair divided by 360.

1 Cycle (C): 360 electrical degrees (° e), 1 bar and window pair.

1 Shaft Rotation: 360 mechanical degrees, N cycles.

Position Error ($\Delta\Theta$): The normalized angular difference between the actual shaft position and its position as indicated by the encoder cycle count.

Cycle Error (ΔC): An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

Pulse Width (P): The number of electrical degrees that an output is high during 1 cycle. This value is nominally 180° e or 1/2 cycle.

Pulse Width Error (ΔP): The deviation, in electrical degrees, of the pulse width from its ideal value of 180° e.

State Width (S): The number of electrical degrees between a transition in the output of channel A and the neighboring transition in the output of channel B. There are 4 states per cycle, each nominally 90° e.

State Width Error (ΔS): The deviation, in electrical degrees, of each state width from its ideal value of 90° e.

Phase (ϕ): The number of electrical degrees between the center of the high state of channel A and the center of the high state of channel B. This value is nominally 90° e for quadrature output.

Phase Error ($\Delta\phi$): The deviation of the phase from its ideal value of 90° e.

Direction of Rotation: When the code wheel rotates in the counterclockwise direction (as viewed from the encoder end of the motor), channel A will lead channel B. When the code wheel rotates in the clockwise direction, channel B will lead channel A.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Storage Temperature	T_S	-40		100	Celsius	
Operating Temperature	T_A	-40		100	Celsius	
Supply Voltage	V_{CC}	-0.5		7	Volts	
Output Voltage	V_O	-0.5		V_{CC}	Volts	
Output Current per Channel	I_O	-1.0		5	mA	
Vibration				20	g	5 to 1000 Hz
Shaft Axial Play				±0.25 ±(0.010)	mm (inch)	
Shaft Eccentricity Plus Radial Play				0.1 (0.004)	mm (inch) TIR	
Velocity				30 K	R.P.M.	
Acceleration				250 K	Rad/Sec^2	

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Notes
Temperature	T_A	-40	100	Celsius	
Supply Voltage	V_{CC}	4.5	5.5	Volts	Ripple < 100 mV_{P-P}
Load Capacitance	C_L		100	pF	3.2 k pull-up resistor
Count Frequency[1]	f		100	kHZ	$\frac{\text{Velocity (rpm) x N}}{60}$
Shaft Perpendicularity Plus Axial Play			±0.25 ±(0.010)	mm (inch)	6.9 mm (0.27 inch) from mounting surface
Shaft Eccentricity Plus Radial Play			0.04 (0.0015)	mm (inch) TIR	6.9 mm (0.27 inch) from mounting surface

Note:
1. The encoder performance is guaranteed to 100 kHz but can operate at higher frequencies.

Encoding Characteristics

Encoding characteristics over Recommended Operating range and recommended mounting tolerances. Values are for the worst error over the full rotation.

Parameter	Symbol	Typ.[2]	Max.	Units	Notes
Pulse Width Error	ΔP	7	45	elec. deg.	
Logic State Width Error	ΔS	5	45	elec. deg.	
Phase Error	$\Delta\phi$	2	20	elec. deg.	
Position Error	$\Delta\Theta$	10	40	minutes of arc	
Cycle Error	ΔC	3	5.5	elec. deg.	

Note:
2. Typical errors are computed as the absolute value of the mean error.

Mechanical Characteristics

Parameter	Symbol	Dimension	Tolerance	Units
Standard Shaft Diameters		2 3 4 5 6	+0.000 -0.015	mm
		5/32 1/8 3/16 1/4	+0.0000 -0.0007	inches
Moment of Inertia	J	0.6 (8.0×10^{-6})		gcm^2 ($oz\text{-}in\text{-}s^2$)
Required Shaft Length[3]		14.0 (0.55)	±0.5 (±0.02)	mm (inches)
Bolt Circle	2 screw mounting	19.05 (0.750)	±0.13 (±0.005)	mm (inches)
	3 screw mounting	20.90 (0.823)	±0.13 (±0.005)	mm (inches)
Mounting Screw Size	2 screw mounting	M 2.5 or (2-56)		mm (inches)
	3 screw mounting	M 1.6 or (0-80)		mm (inches)
Encoder Base Plate Thickness		0.33 (0.130)		mm (inches)
Hub Set Screw		(2-56)		(inches)

Note:

3. An 8.9 mm (0.35") diameter hole through the housing of the HEDS-5500 is available for extended motor shafts. Please consult your Hewlett-Packard sales representative for further information.

Electrical Characteristics

Electrical Characteristics over Recommended Operating Range, typical at 25° C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}		17	40	mA	
High Level Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -40 μA Max.
Low Level Output Voltage	V_{OL}			0.4	Volts	I_{OL} = 3.2 mA
Rise Time	t_r		200		ns	C_L = 25 pF
Fall Time	t_f		50		ns	R_L = 11 K Pull-up

Note:

1. For improved performance in noisy environments or high speed applications, a 3.3 kΩ pull-up resistor is recommended.

Suggested Connectors

Manufacturer	Part Number
AMP	103686-4
	640442-5
Berg	65039-032 with 4825X-000 terminals
	65801-034
Molex	2695 series with 2759 series terminals

Ordering Information

HEDS-5500 Option ☐ ☐☐

Resolution[4] (Cycles per revolution)		
K - 96 CPR	E - 200 CPR	H - 400 CPR
C - 100 CPR	F - 256 CPR	A - 500 CPR
D - 192 CPR	G - 360 CPR	I - 512 CPR

Shaft Diameter	
01 - 2 mm	06 - 1/4 in.
02 - 3 mm	11 - 4 mm
03 - 1/8 in.	12 - 6 mm
05 - 3/16 in.	14 - 5 mm
04 - 5/32 in.	

Note:
4. Other code wheel resolutions are available. Please consult your Hewlett-Packard sales representative for further information.

Mounting Considerations

The HEDS - 5500 can be mounted to a motor using either the two screw or three screw mounting option as shown in figure 1. If the encoder is attached to the motor with the screw sizes and mounting tolerances specified in the encoding characteristics section without any additional mounting bosses, the encoder output errors will be within the maximums specified in the encoding characteristics section.

The optional alignment pins shown in figure 2 can be used with either the two or three screw mounting option to improve the alignment of the encoder to the motor. This improved alignment will result in better encoder performance.

The best encoder performance will be obtained by mounting the encoder onto the motor using the optional motor boss with either the two or three screw mounting option as shown in figure 2.

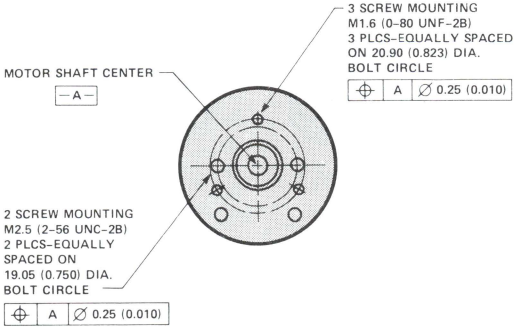


Figure 1. Mounting Holes

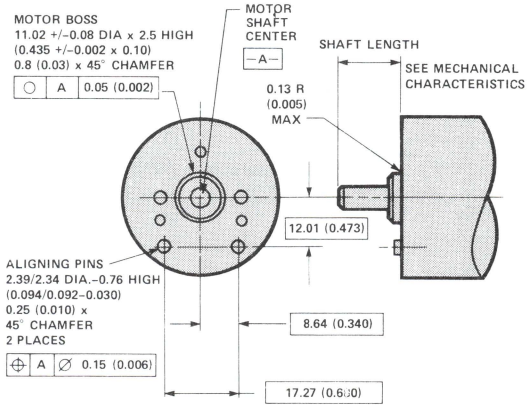
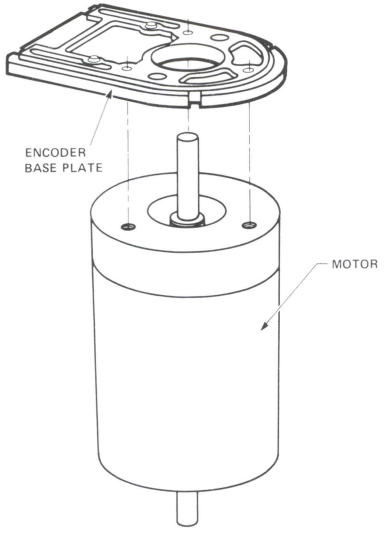
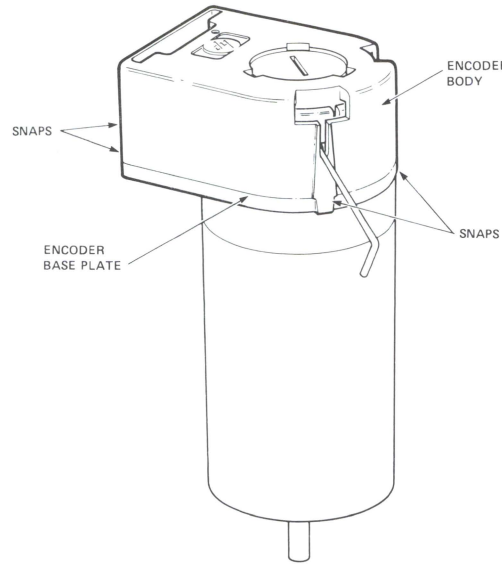


Figure 2. Optional Mounting Aids

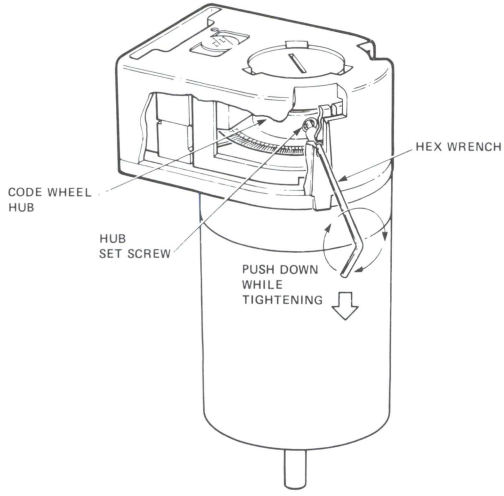
Encoder Mounting and Assembly



1. Mount encoder base plate onto motor. Tighten screws. (Reference page 5 for mounting considerations).



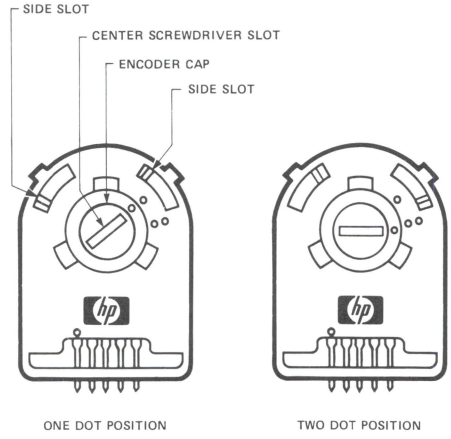
2. Snap encoder body onto base plate locking all 4 snaps.



3a. Push the hex wrench into the body of the encoder to ensure that it is properly seated into the code wheel hub set screw. Then apply a downward force on the end of the hex wrench. This sets the code wheel gap by levering the code wheel hub to its upper position.

3b. While continuing to apply a downward force, rotate the hex wrench in the clockwise direction until the hub set screw is tight against the motor shaft. The hub set screw attaches the code wheel to the motor's shaft.

3c. Remove the hex wrench by pulling it straight out of the encoder body.



4. Use the center screwdriver slot, or either of the two side slots, to rotate the encoder cap dot clockwise from the one dot position to the two dot position. Do not rotate the encoder cap counter-clockwise beyond the one dot position.

The encoder is ready for use!

HEWLETT PACKARD

28 mm DIAMETER TWO AND THREE CHANNEL INCREMENTAL OPTICAL ENCODER KIT

HEDS-5000 SERIES

TECHNICAL DATA JANUARY 1986

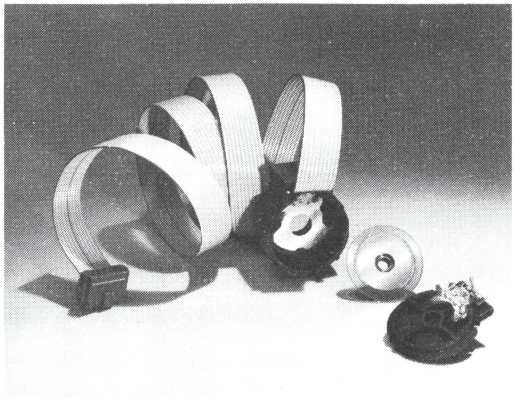
Features

- **SMALL SIZE — 28 mm DIAMETER**
- **100-512 CYCLES/REVOLUTION AVAILABLE**
- **MANY RESOLUTIONS STANDARD**
- **LOW INERTIA**
- **QUICK ASSEMBLY**
- **0.25 mm (.010 INCHES) END PLAY ALLOWANCE**
- **TTL COMPATIBLE DIGITAL OUTPUT**
- **SINGLE 5V SUPPLY**
- **WIDE TEMPERATURE RANGE**
- **INDEX PULSE AVAILABLE**

Description

The HEDS-5000 series is a high resolution incremental optical encoder kit emphasizing reliability and ease of assembly. The 28 mm diameter package consists of 3 parts: the encoder body, a metal code wheel, and an emitter end plate. An LED source and lens transmit collimated light from the emitter module through a precision metal code wheel and phase plate into a bifurcated detector lens.

The light is focused onto pairs of closely spaced integrated detectors which output two square wave signals in quadrature and an optional index pulse. Collimated light and a custom photodetector configuration increase long life reliability by reducing sensitivity to shaft end play, shaft eccentricity and LED degradation. The outputs and the 5V supply input of the HEDS-5000 are accessed through a 10 pin connector mounted on a .6 metre ribbon cable.

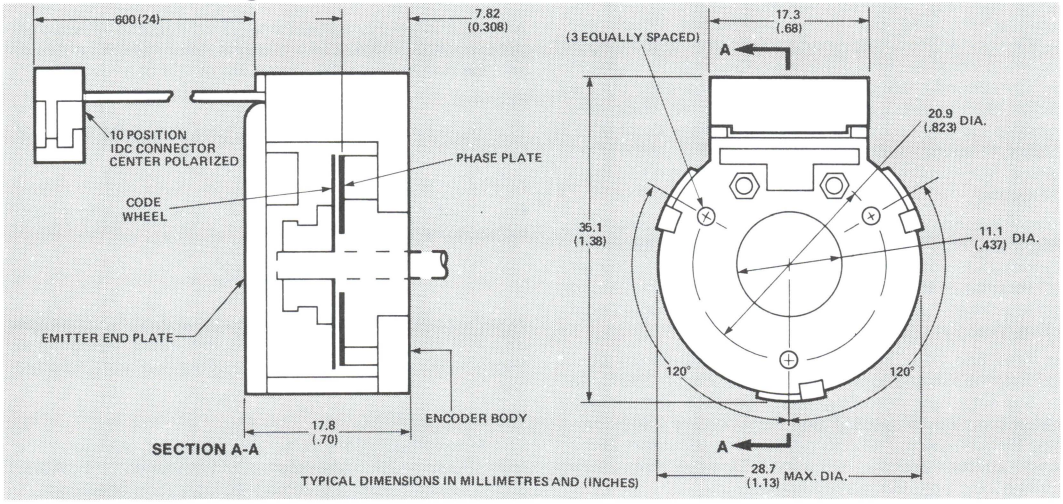


A standard selection of shaft sizes and resolutions between 100 and 512 cycles per revolution are available. Consult the factory for custom resolutions. The part number for the standard 2 channel kit is HEDS-5000, while that for the 3 channel device, with index pulse, is HEDS-5010. See Ordering Information for more details. For additional design information, see Application Note 1011.

Applications

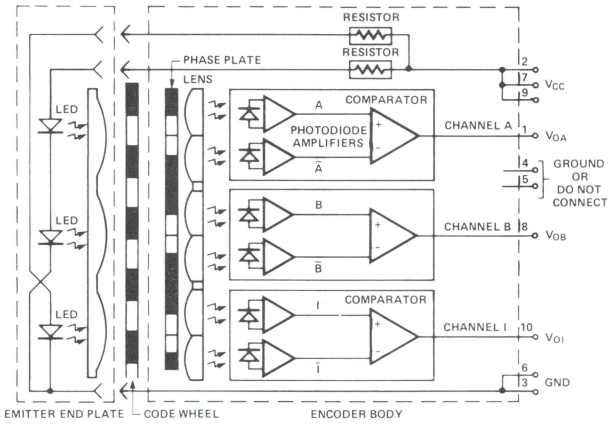
Printers, Plotters, Tape Drives, Positioning Tables, Automatic Handlers, Robots, and any other servo loop where a small high performance encoder is required.

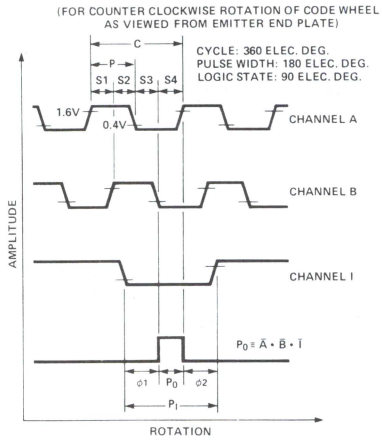
Outline Drawing



MOTION SENSING AND CONTROL

Block Diagram and Output Waveforms





Theory of Operation

The incremental shaft encoder operates by translating the rotation of a shaft into interruptions of a light beam which are then output as electrical pulses.

In the HEDS-5XXX the light source is a Light Emitting Diode collimated by a molded lens into a parallel beam of light. The Emitter End Plate contains two or three similar light sources, one for each channel.

The standard Code Wheel is a metal disc which has N equally spaced apertures around its circumference. A matching pattern of apertures is positioned on the stationary phase plate. The light beam is transmitted only when the apertures in the code wheel and the apertures in the phase plate line up; therefore, during a complete shaft revolution, there will be N alternating light and dark periods. A molded lens beneath the phase plate aperture collects the modulated light into a silicon detector.

The Encoder Body contains the phase plate and the detection elements for two or three channels. Each channel consists of an integrated circuit with two photodiodes and amplifiers, a comparator, and output circuitry.

The apertures for the two photodiodes are positioned so that a light period on one detector corresponds to a dark period on the other ("push-pull"). The photodiode signals are amplified and fed to the comparator whose output changes state when the difference of the two photocurrents changes sign. The second channel has a similar configuration but the location of its aperture pair provides an output which is in quadrature to the first channel (phase difference of 90°). Direction of rotation is determined by observing which of the channels is the leading waveform. The outputs are TTL logic level signals.

The optional index channel is similar in optical and electrical configuration to the A and B channels previously described. An index pulse of typically 1 cycle width is generated for each rotation of the code wheel. Using the recommended logic interface, a unique logic state (P_0) can be identified if such accuracy is required.

The three part kit is assembled by attaching the Encoder Body to the mounting surface using three screws. The Code Wheel is set to the correct gap and secured to the shaft. Snapping the cover (Emitter End Plate) on the body completes the assembly. The only adjustment necessary is the encoder centering relative to the shaft. This optimizes quadrature and the optional index pulse outputs.

Index Pulse Considerations

The motion sensing application and encoder interface circuitry will determine the necessary phase relationship of the index pulse to the main data tracks. A unique shaft position can be identified by using the index pulse output only or by logically relating the index pulse to the A and B data channels. The HEDS-5010 allows some adjustment of the index pulse position with respect to the main data channels. The position is easily adjusted during the assembly process as illustrated in the assembly procedures.

Definitions

Electrical degrees:

1 shaft rotation = 360 angular degrees
= N electrical cycles

1 cycle = 360 electrical degrees

Position Error:

The angular difference between the actual shaft position and its position as calculated by counting the encoder's cycles.

Cycle Error:

An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

Phase:

The angle between the center of Pulse A and the center of Pulse B.

Index Phase:

For counter clockwise rotation as illustrated above, the Index Phase is defined as:

$$\Phi_1 = \frac{(\phi_1 - \phi_2)}{2}.$$

ϕ_1 is the angle, in electrical degrees between the falling edge of I and falling edge of B. ϕ_2 is the angle, in electrical degrees, between the rising edge of A and the rising edge of I.

Index Phase Error:

The Index Phase Error ($\Delta\Phi_I$) describes the change in the Index Pulse position after assembly with respect to the A and B channels over the recommended operating conditions.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	-55	100	°Celsius	
Operating Temperature	T_A	-55	100	°Celsius	See Note 1
Vibration			20	g	See Note 1
Shaft Axial Play			.50 (20)	mm(1inch/1000) TIR	
Shaft Eccentricity Plus Radial Play			.1 (4)	mm(1inch/1000) TIR	Movement should be limited even under shock conditions.
Supply Voltage	V_{CC}	-0.5	7	Volts	
Output Voltage	V_O	-0.5	V_{CC}	Volts	
Output Current per Channel	I_O	-1	5	mA	
Velocity			30,000	R.P.M.	
Acceleration	α		250,000	Rad. Sec^{-2}	

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Notes
Temperature	T	-20	85	°Celsius	Non-condensing atmos.
Supply Voltage	Vcc	4.5	5.5	Volt	Ripple < $100mV_{p-p}$
Code Wheel Gap			1.1 (45)	mm (inch/1000)	Nominal gap =
Shaft Perpendicularity Plus Axial Play			0.25 (10)	mm (inch/1000) TIR	0.63 mm (.025 in.) when shaft is at minimum gap position.
Shaft Eccentricity Plus Radial Play			0.04 (1.5)	mm (inch/1000) TIR	10 mm (0.4 inch) from mounting surface.
Load Capacitance	C_L		100	pF	

Encoding Characteristics

The specifications below apply within the recommended operating conditions and reflect performance at 500 cycles per revolution (N = 500). Some encoding characteristics improve with decreasing cycles (N). Consult Application Note 1011 or factory for additional details.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes (See Definitions)
Position Error - Worst Error Full Rotation	$\Delta\Theta$		10	40	Minutes of Arc	1 Cycle = 43.2 Minutes See Figure 5.
Cycle Error - Worst Error Full Rotation	ΔC		3	5.5	Electrical deg.	
Max. Count Frequency	f_{MAX}	130,000	200,000		Hertz	f = Velocity (RPM) x N/60
Pulse Width Error - Worst Error Full Rotation	ΔP		16		Electrical deg.	T = 25° C, f = 8 KHz See Note 2
Phase Sensitivity to Eccentricity			520 (13)		Elec. deg./mm (Elec. deg./mil)	mil = inch/1000
Phase Sensitivity to Axial Play			20 (.5)		Elec. deg./mm (Elec. deg./mil)	mil = inch/1000
Logic State Width Error - Worst Error Full Rotation	ΔS		25		Electrical deg.	T = 25° C, f = 8 KHz See Note 2
Index Pulse Width	P_I		360		Electrical deg.	T = 25° C, f = 8 KHz See Note 3
Index Phase Error	$\Delta\Phi_I$		0	17	Electrical deg.	See Notes 4, 5
Index Pulse Phase Adjustment Range		±70	±130		Electrical deg.	See Note 5

Mechanical Characteristics

Parameter	Symbol	Dimension	Tolerance	Units	Notes
Outline Dimensions		See Mech. Dwg.			
Code Wheel Available to Fit the Following Standard Shaft Diameters		2 4 3 5	+.000 −.015	mm	
		5/32	+.0002 −.0005	inches	
		1/8 3/16 1/4	+.0000 −.0007	inches	
Moment of Inertia	J	0.4 (6 x 10^{-6})		gcm² (oz-in-s²)	
Required Shaft Length		12.8 (.50)	±0.5 (±0.02)	mm (inches)	See Figure 10. Shaft in minimum length position.
Bolt Circle		20.9 (.823)	±0.13 (±.005)	mm (inches)	See Figure 10.
Mounting Screw Size		1.6 x 0.35 x 5 mm DIN 84 or 0-80 x 3/16 Binding Head		mm inches	

Electrical Characteristics When operating within the recommended operating range.

Electrical Characteristics over Recommended Operating Range (Typical at 25° C).

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}		21	40	mA	HEDS-5000 (2 Channel)
			36	60		HEDS-5010 (3 Channel)
High Level Output Voltage	V_{OH}	2.4			V	I_{OH} = -40μA Max.
Low Level Output Voltage	V_{OL}			0.4	V	I_{OL} = 3.2 mA
Rise Time	t_r		0.5		μs	C_L = 25 pF, R_L = 11K Pull-up
Fall Time	t_f		0.2			See Note 6
Cable Capacitance	C_{CO}		12		pF/metres	Output Lead to Ground

NOTES:

1. The structural parts of the HEDS-5000 have been tested to 20g and up to 500 Hz. For use outside this range, operation may be limited at low frequencies (high displacement) by cable fatigue and at high frequencies by code wheel resonances. Resonant frequency depends on code wheel material and number of counts per revolution. For temperatures below -20° C the ribbon cable becomes brittle and sensitive to displacements. Maximum operating and storage temperature includes the surface area of the encoder mounting. Consult factory for further information. See Application Note 1011.
2. In a properly assembled lot 99% of the units, when run at 25° C and 8 KHz, should exhibit a pulse width error less than 35 electrical degrees, and a state width error less than 45 electrical degrees. To calculate errors at other speeds and temperatures add the values specified in Figures 1 or 2 to the typical values specified under encoding characteristics or to the maximum 99% values specified in this note.
3. In a properly assembled lot, 99% of the units when run at 25° C and 8 KHz should exhibit an index pulse width greater than 260 electrical degrees and less than 460 electrical degrees. To calculate index pulse widths at other speeds and temperatures add the values specified in Figures 3 or 4 to the typical 360° pulse width or to the maximum 99% values specified in this note.
4. After adjusting index phase at assembly, the index phase error specification ($\Delta\Phi$I) indicates the expected shift in index pulse position with respect to channels A and B over the range of recommended operating conditions and up to 50 KHz.
5. When the index pulse is centered on the low-low states of channels A and B as shown on page 2, a unique P_O can be defined once per revolution within the recommended operating conditions and up to 25 KHz. Figure 6 shows how P_O can be derived from A, B, and I outputs. The adjustment range indicates how far from the center of the low-low state that the center of the index pulse may be adjusted.
6. The rise time is primarily a function of the RC time constant of R_L and C_L. A faster rise time can be achieved with either a lower value of R_L or C_L. Care must be observed not to exceed the recommended value of I_{OL} under the worst case conditions.

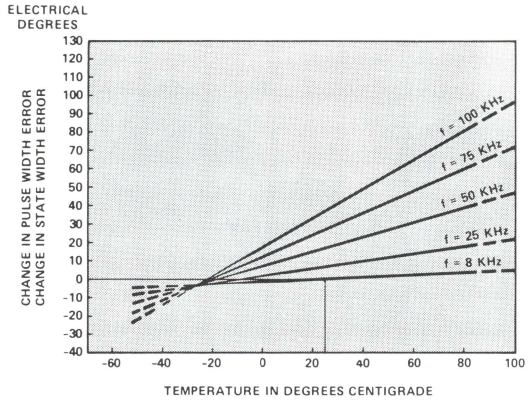


Figure 1. Typical Change in Pulse Width Error or in State Width Error due to Speed and Temperature

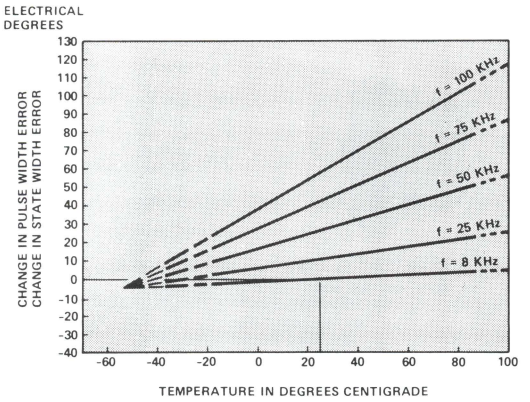


Figure 2. Maximum Change in Pulse Width Error or in State Width Error Due to Speed and Temperature

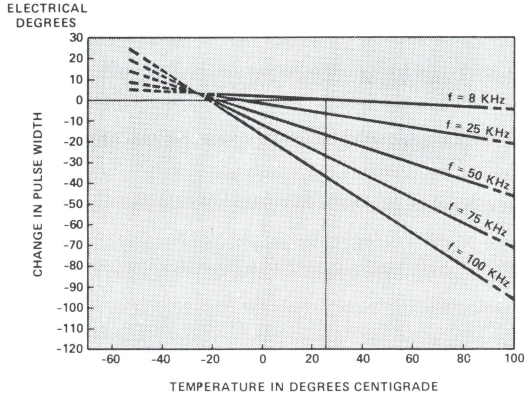


Figure 3. Typical Change in Index Pulse Width Due to Speed and Temperature

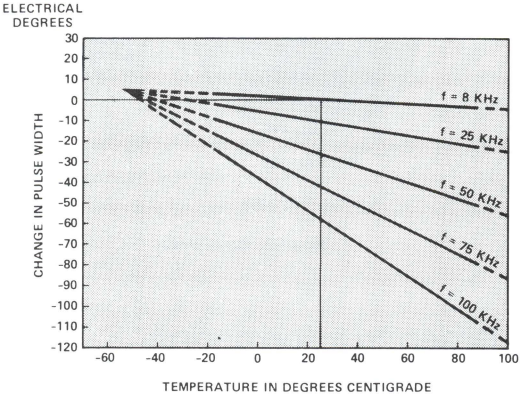


Figure 4. Maximum Change in Index Pulse Width Due to Speed and Temperature

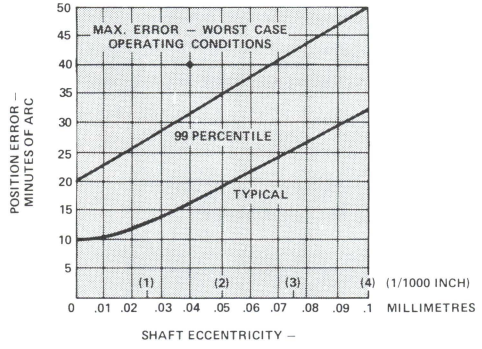
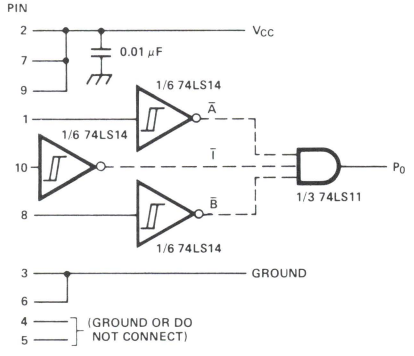
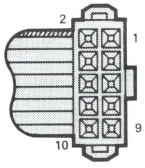


Figure 5. Position Error vs. Shaft Eccentricity



DASHED LINES REPRESENT AN OPTIONAL INDEX SUMMING CIRCUIT. STANDARD 74 SERIES COULD ALSO BE USED TO IMPLEMENT THIS CIRCUIT.

Figure 6. Recommended Interface Circuit



BOTTOM VIEW

PINOUT

PIN #	FUNCTION
1	CHANNEL A
2	V_{CC}
3	GROUND
4	N.C. OR GROUND
5	N.C. OR GROUND
6	GROUND
7	V_{CC}
8	CHANNEL B
9	V_{CC}
10	CHANNEL I

NOTE: REVERSE INSERTION OF THE CONNECTOR WILL PERMANENTLY DAMAGE THE DETECTOR IC.

MATING CONNECTOR
BERG 65-692-001 OR EQUIVALENT

Figure 7. Connector Specifications

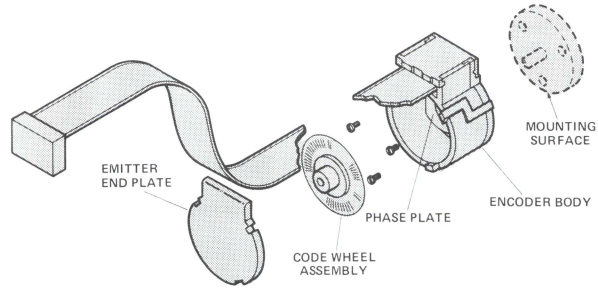
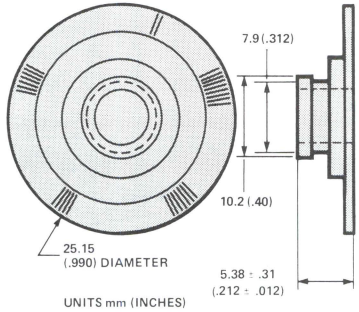
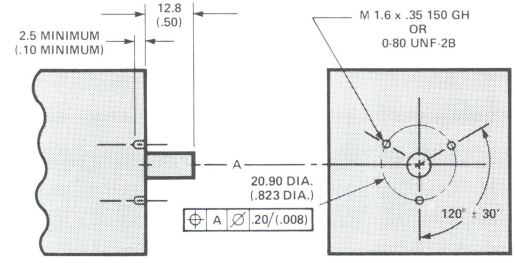


Figure 8. HEDS-5000 Series Encoder Kit



UNITS mm (INCHES)

Figure 9. Code Wheel



MILLIMETRE .X ± .5 .XX ± .10
(INCHES) (.XX ± .02 .XXX ± .005)

Figure 10. Mounting Requirements

Ordering Information

HEDS-5 □□□

OPTION* □□

RESOLUTION (CYCLES PER REVOLUTION)

C – 100 CPR	G – 360 CPR
D – 192 CPR	H – 400 CPR
E – 200 CPR	A – 500 CPR
F – 256 CPR	I – 512 CPR

NOTE: OTHER RESOLUTIONS AVAILABLE ON SPECIAL REQUEST.

SHAFT DIAMETER

01 – 2 mm
02 – 3 mm
03 – 1/8 in.
04 – 5/32 in.
05 – 3/16 in.
06 – 1/4 in.
11 – 4 mm
12 – 6 mm
14 – 5 mm
00 – USE WHEN ORDERING ENCODER BODIES

PRODUCT TYPE

0 – 28 mm COMPLETE KIT
1 – 28 mm CODE WHEEL
2 – 28 mm ENCODER BODY
3 – 28 mm EMITTER END PLATE*

OUTPUTS

0 – 2 CHANNEL DIGITAL
1 – 3 CHANNEL DIGITAL

MECHANICAL CONFIGURATION

0 – 0.6 m (24 in.) CABLE

*NO OPTION IS SPECIFIED WHEN ORDERING EMITTER END PLATES ONLY.

Shaft Encoder Kit Assembly **See Application Note 1011 for further discussion.**

The following assembly procedure represents a simple and reliable method for prototype encoder assembly. High volume assembly may suggest modifications to this procedure using custom designed tooling. In certain high volume applications encoder assembly can be accomplished in less than 30 seconds. Consult factory for further details. Note: The code wheel to phase plate gap should be set between 0.015 in. and 0.045 in.

WARNING: THE ADHESIVES USED MAY BE HARMFUL. CONSULT THE MANUFACTURER'S RECOMMENDATIONS.

READ THE INSTRUCTIONS TO THE END BEFORE STARTING ASSEMBLY.

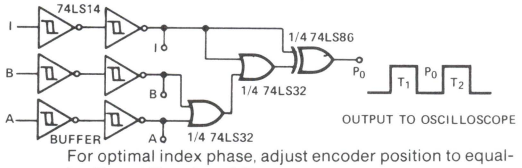
1.0 SUGGESTED MATERIALS

1.1 Encoder Parts
Encoder Body
Emitter End Plate
Code Wheel

1.2 Assembly Materials
RTV — General Electric 162
— Dow Corning 3145
Epoxy—Hysol 1C
Acetone
Mounting Screws (3)
RTV and Epoxy Applicators

1.3 Suggested Assembly Tools
a) Holding Screwdriver.
b) Torque Limiting Screwdriver, 0.36 cm kg (5.0 in. oz.).
c) Depth Micrometer or HEDS-8922 Gap Setter.
d) Oscilloscope or Phase Meter (Described in AN 1011). Either may be used for two channel phase adjustment. An oscilloscope is required for index pulse phase adjustment.

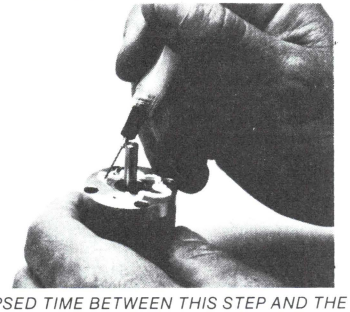
1.4 Suggested Circuits
a) Suggested circuit for index adjustment (HEDS-5010).



For optimal index phase, adjust encoder position to equalize T_1 and T_2 pulse widths.

b) Phase Meter Circuit
Recommended for volume assembly. Please see Application Note 1011 for details.

2.0 SURFACE PREPARATION



THE ELAPSED TIME BETWEEN THIS STEP AND THE COMPLETION OF STEP 8 SHOULD NOT EXCEED 1/2 HOUR.

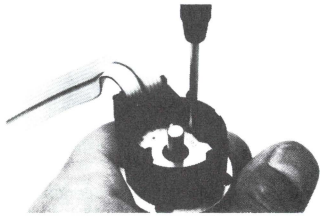
2.1 Clean and degrease with acetone the mounting surface and shaft making sure to keep the acetone away from the motor bearings.

2.2 Load the syringe with RTV.

2.3 Apply RTV into screw threads on mounting surface. Apply more RTV on the surface by forming a daisy ring pattern connecting the screw holes as shown above.

CAUTION: KEEP RTV AWAY FROM THE SHAFT BEARING.

3.0 ENCODER BODY ATTACHMENT

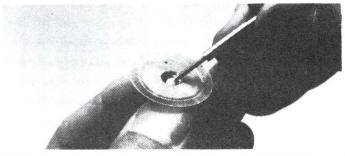


3.1 Place the encoder body on the mounting surface and slowly rotate the body to spread the adhesive. Align the mounting screw holes with the holes in the body base.

3.2 Place the screws in the holding screwdriver and thread them into the mounting holes. Tighten to approximately 0.36 cm kg (5.0 in. oz.) using a torque limiting screwdriver if available (See notes a and b below). Remove centering cone if used.

Notes:
a) At this torque value, the encoder body should slide on the mounting surface only with considerable thumb pressure.
b) The torque limiting screwdriver should be periodically calibrated for proper torque.

4.0 EPOXY APPLICATION



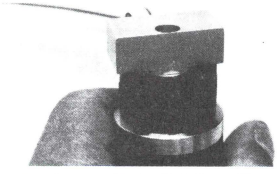
CAUTION: HANDLE THE CODE WHEEL WITH CARE.

4.1 Collect a small dab of epoxy on an applicator.

4.2 Spread the epoxy inside the lower part of the hub bore.

4.3 Holding the code wheel by its hub, slide it down the shaft just enough to sit it squarely. About 3 mm (1/8").

5.0 CODE WHEEL POSITIONING



5.1 Take up any loose play by lightly pulling down on the shaft's load end.

5.2 Using the gap setter or a depth micrometer, push the code wheel hub down to a depth of 1.65 mm (.065 in.) below the rim of the encoder body. The registration holes in the gap setter will align with the snaps protruding from the encoder body near the cable.

5.3 Check that the gap setter or micrometer is seated squarely on the body rim and maintains contact with the code wheel hub.

5.4 No epoxy should extrude through the shaft hole.

DO NOT TOUCH THE CODE WHEEL AFTER ASSEMBLY.

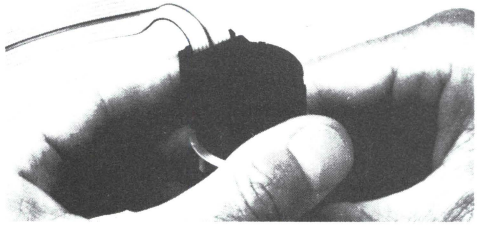
6.0 EMITTER END PLATE

6.1 Visually check that the wire pins in the encoder body are straight and straighten if necessary.

6.2 Hold the end plate parallel to the encoder body rim. Align the guiding pin on the end plate with the hole in the encoder body and press the end plate straight down until it is locked into place.

6.3 Visually check to see if the end plate is properly seated.

7.0 PHASE ADJUSTMENT



7.1 The following procedure should be followed when phase adjusting channels A and B.

7.2 Connect the encoder cable.

7.3 Run the motor. Phase corresponds to motor direction. See output waveforms and definitions. Using either an oscilloscope or a phase meter, adjust the encoder for minimum phase error by sliding the encoder forward or backward on the mounting surface as shown above. See Application Note 1011 for the phase meter circuit.

7.4 No stress should be applied to the encoder package until the RTV cures. Cure time is 2 hours @ 70° C or 24 hrs. at room temperature.

Note: After mounting, the encoder should be free from mechanical forces that could cause a shift in the encoder's position relative to its mounting surface.

CODE WHEEL REMOVAL

In the event that the code wheel has to be removed after the epoxy has set, use the code wheel extractor as follows:

1 Remove the emitter end plate by prying a screwdriver in the slots provided around the encoder body rim. Avoid bending the wire leads.

2 Turn the screw on the extractor counter-clockwise until the screw tip is no longer visible.

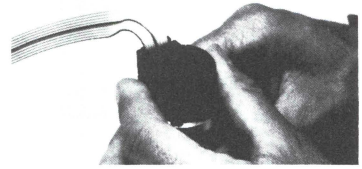
3 Slide the extractor's horseshoe shaped lip all the way into the groove on the code wheel's hub.

4 While holding the extractor body stationary, turn the thumb screw clockwise until the screw tip pushes against the shaft.

5 Applying more turning pressure will pull the hub upwards breaking the epoxy bond.

6 Clean the shaft before reassembly.

8.0 INDEX PULSE ADJUSTMENT (HEDS-5010)



8.1 Some applications require that the index pulse be aligned with the main data channels. The index pulse position and the phase must be adjusted simultaneously. This procedure sets index phase to zero.

8.2 Connect the encoder cable.

8.3 Run the motor. Adjust for minimum phase error using an oscilloscope or phase meter (see 7.3).

8.4 Using an oscilloscope and the circuit shown in 1.4, set the trigger for the falling edge of the I output. Adjust the index pulse so that T_1 and T_2 are equal in width. The physical adjustment is a side to side motion as shown by the arrow.

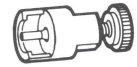
8.5 Recheck the phase adjustment.

8.6 Repeat steps 8.3-8.5 until both phase and index pulse position are as desired.

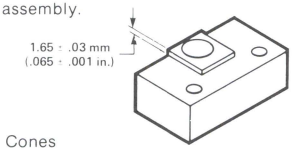
8.7 No stress should be applied to the encoder package until the RTV has cured. Cure time: 2 hours @ 70° C or 24 hrs. at room temperature.

SPECIALITY TOOLS — Available from Hewlett-Packard

a) HEDS-8920 Hub Puller
This tool may be used to remove code wheels from shafts after the epoxy has cured.



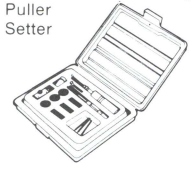
b) HEDS-8922 Gap Setter
This tool may be used in place of a depth micrometer as an aid in large volume assembly.



c) HEDS-892X Centering Cones
For easier volume assembly this tool in its appropriate shaft size may be used in step 3.0 to initially center the encoder body with respect to the shaft and aid in locating the mounting screw holes. Depending on the resolution and accuracy required this centering may eliminate the need for phase adjustment steps 7 and 8.

Part Number	Shaft Size
HEDS-8923	2 mm
HEDS-8924	3 mm
HEDS-8925	1/8 in.
HEDS-8926	5/32 in.
HEDS-8927	3/16 in.
HEDS-8928	1/4 in.
HEDS-8929	4 mm
HEDS-8931	5 mm

d) HEDS-8930 HEDS-5000 Tool Kit
1 Holding Screwdriver
1 Torque Limiting Screwdriver, 0.36 cm kg (5.0 in. oz.)
1 HEDS-8920 Hub Puller
1 HEDS-8922 Gap Setter
1 Carrying Case



HEWLETT PACKARD

56 mm DIAMETER TWO AND THREE CHANNEL INCREMENTAL OPTICAL ENCODER KIT

HEDS-6000 SERIES

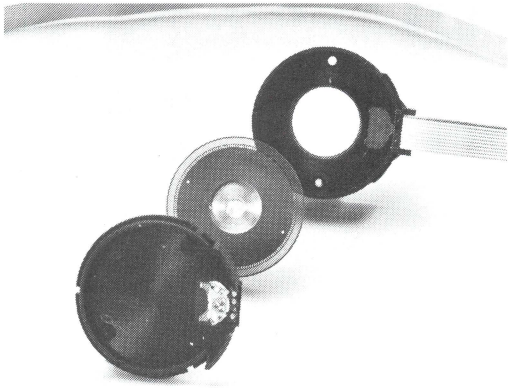
Features

- 192-1024 CYCLES/REVOLUTION AVAILABLE
- MANY RESOLUTIONS STANDARD
- QUICK ASSEMBLY
- 0.25 mm (.010 INCHES) END PLAY ALLOWANCE
- TTL COMPATIBLE DIGITAL OUTPUT
- SINGLE 5V SUPPLY
- WIDE TEMPERATURE RANGE
- SOLID STATE RELIABILITY
- INDEX PULSE AVAILABLE

Description

The HEDS-6000 series is a high resolution incremental optical encoder kit emphasizing ease of assembly and reliability. The 56 mm diameter package consists of 3 parts: the encoder body, a metal code wheel, and emitter end plate. An LED source and lens transmit collimated light from the emitter module through a precision metal code wheel and phase plate into a bifurcated detector lens.

The light is focused onto pairs of closely spaced integrated detectors which output two square wave signals in quadrature and an optional index pulse. Collimated light and a custom photodetector configuration increase long life reliability by reducing sensitivity to shaft end play, shaft eccentricity and LED degradation. The outputs and the 5V supply input of the HEDS-6000 are accessed through a 10 pin connector mounted on a .6 metre ribbon cable.

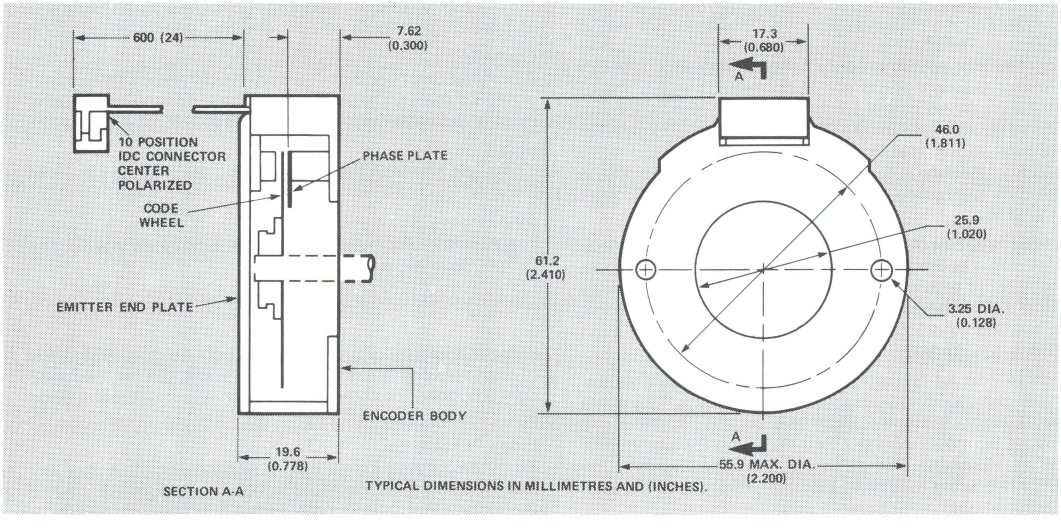


A standard selection of shaft sizes and resolutions between 192 and 1024 cycles per revolution are available. Consult the factory for custom resolutions. The part number for the standard 2 channel bit is HEDS-6000, while that for the 3 channel device, with index pulse, is HEDS-6010. See Ordering Information for more details. For additional design information, see Application Note 1011.

Applications

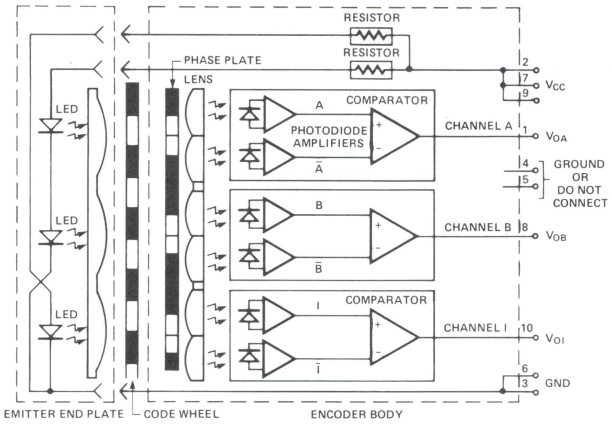
Printers, Plotters, Tape Drives, Positioning Tables, Automatic Handlers, Robots, and any other servo loop where a small high performance encoder is required.

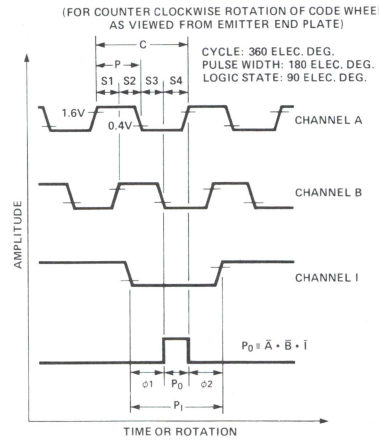
Outline Drawing



MOTION SENSING AND CONTROL

Block Diagram and Output Waveforms





Theory of Operation

The incremental shaft encoder operates by translating the rotation of a shaft into interruptions of a light beam which are then output as electrical pulses.

In the HEDS-6XXX the light source is a Light Emitting Diode collimated by a molded lens into a parallel beam of light. The Emitter End Plate contains two or three similar light sources, one for each channel.

The standard Code Wheel is a metal disc which has N equally spaced slits around its circumference. An aperture with a matching pattern is positioned on the stationary phase plate. The light beam is transmitted only when the slits in the code wheel and the aperture line up; therefore, during a complete shaft revolution, there will be N alternating light and dark periods. A molded lens beneath the phase plate aperture collects the modulated light into a silicon detector.

The Encoder Body contains the phase plate and the detection elements for two or three channels. Each channel consists of an integrated circuit with two photodiodes and amplifiers, a comparator, and output circuitry.

The apertures for the two photodiodes are positioned so that a light period on one detector corresponds to a dark period on the other. The photodiode signals are amplified and fed to the comparator whose output changes state when the difference of the two photo currents changes sign ("Push-Pull"). The second channel has a similar configuration but the location of its aperture pair provides an output which is in quadrature to the first channel (phase difference of 90°). Direction of rotation is determined by observing which of the channels is the leading waveform. The outputs are TTL logic level signals.

The optional index channel is similar in optical and electrical configuration to the A,B channels previously described. An index pulse of typically 1 cycle width is generated for each rotation of the code wheel. Using the recommended logic interface, a unique logic state (P_0) can be identified if such accuracy is required.

The three part kit is assembled by attaching the Encoder Body to the mounting surface using two screws. The Code Wheel is set to the correct gap and secured to the shaft. Snapping the cover (Emitter End Plate) on the body completes the assembly. The only adjustment necessary is the encoder centering relative to the shaft, to optimize quadrature and optional index pulse output.

Index Pulse Considerations

The motion sensing application and encoder interface circuitry will determine the need for relating the index pulse to the main data tracks. A unique shaft position is identified by using the index pulse output only or by logically relating the index pulse to the A and B data channels. The HEDS-6010 index pulse can be uniquely related with the A and B data tracks in a variety of ways providing maximum flexibility. Statewidth, pulse width or edge transitions can be used. The index pulse position, with respect to the main data channels, is easily adjusted during the assembly process and is illustrated in the assembly procedures.

Definitions

Electrical degrees:
1 shaft rotation = 360 angular degrees
= N electrical cycles
1 cycle = 360 electrical degrees

Position Error:
The angular difference between the actual shaft position and its position as calculated by counting the encoder's cycles.

Cycle Error:
An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

Phase:
The angle between the center of Pulse A and the center of Pulse B.

Index Phase:
For counter clockwise rotation as illustrated above, the Index Phase is defined as:

$$\Phi_I = \frac{(\phi_1 - \phi_2)}{2}.$$

ϕ_1 is the angle, in electrical degrees, between the falling edge of I and falling edge of B. ϕ_2 is the angle, in electrical degrees, between the rising edge of A and the rising edge of I.

Index Phase Error:
The Index Phase Error ($\Delta\Phi_I$) describes the change in the Index Pulse position after assembly with respect to the A and B channels over the recommended operating conditions.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	-55	100	°Celsius	
Operating Temperature	T_A	-55	100	°Celsius	See Note 1
Vibration			20	g	See Note 1
Shaft Axial Play			.58 (23)	mm (inch/1000) TIR	
Shaft Eccentricity Plus Radial Play			.25 (10)	mm (inch/1000) TIR	Movement should be limited even under shock conditions.
Supply Voltage	V_{CC}	-0.5	7	Volts	
Output Voltage	V_O	-0.5	V_{CC}	Volts	
Output Current	I_O	-1	5	mA	
Velocity			12,000	R.P.M.	
Acceleration	α		250,000	Rad. Sec^{-2}	

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Notes
Temperature	T	-20	85	°Celsius	Non-condensing atmos.
Supply Voltage	V_{CC}	4.5	5.5	Volt	Ripple < $100mV_{p-p}$
Code Wheel Gap			1.1 (45)	mm (inch/1000)	Nominal gap = 0.76 mm (.030 in.) when shaft is at minimum gap position.
Shaft Perpendicularity Plus Axial Play			0.25 (10)	mm (inch/1000) TIR	
Shaft Eccentricity Plus Radial Play			0.04 (1.5)	mm (inch/1000) TIR	10 mm (0.4 inch) from mounting surface.
Load Capacitance	C_L		100	pF	

Encoding Characteristics

The specifications below apply within the recommended operating conditions and reflect performance at 1000 cycles per revolution (N = 1000). Some encoding characteristics improve with decreasing cycles (N). Consult Application Note 1011 or factory for additional details.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes (See Definitions)
Position Error	$\Delta\Theta$		7	18	Minutes of Arc	1 Cycle = 21.6 Minutes See Figure 5.
Cycle Error	ΔC		3	5.5	Electrical deg.	
Max. Count Frequency	f_{MAX}	130,000	200,000		Hertz	f = Velocity (RPM) x N/60
Pulse Width Error	ΔP		12		Electrical deg.	T = 25° C, f = 8 KHz See Note 2
Phase Sensitivity to Eccentricity			227 (5.8)		Elec. deg./mm (Elec. deg./mil)	mil = inch/1000
Phase Sensitivity to Axial Play			20 (.5)		Elec. deg./mm (Elec. deg./mil)	mil = inch/1000
Logic State Width Error	ΔS		25		Electrical deg.	T = 25° C, f = 8 KHz See Note 2
Index Pulse Width	P_I		360		Electrical deg.	T = 25° C, f = 8 KHz See Note 3
Index Phase Error	$\Delta\Phi_I$		0	17	Electrical deg.	See Notes 4, 5
Index Pulse Adjustment Range			±165		Electrical deg.	

Mechanical Characteristics

Parameter	Symbol	Dimension	Tolerance	Units	Notes
Outline Dimensions		See Mech. Dwg.			
Code Wheel Available to Fit the Following Standard Shaft Diameters		4 6 8	+.000 −.015	mm	
		3/16 3/8 1/4 1/2 5/16 5/8	+.0000 −.0007	inches	
Moment of Inertia	J	7.7 (110 x 10^{-6})		gcm^2 ($oz\text{-}in\text{-}s^2$)	
Required Shaft Length		15.9 (0.625)	±0.6 (±.024)	mm (inches)	See Figure 10. Shaft at minimum length position.
Bolt Circle		46.0 (1.811)	±0.13 (±.005)	mm (inches)	See Figure 10.
Mounting Screw Size		2.5 x 0.45 x 5 OR #2-56 x 3/16 Pan Head		mm inches	

Electrical Characteristics When operating within the recommended operating range.

Electrical Characteristics over Recommended Operating Range (Typical at 25° C).

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}		21	40	mA	HEDS-6000 (2 Channel)
			36	60		HEDS-6010 (3 Channel)
High Level Output Voltage	V_{OH}	2.4			V	I_{OH} = -40μA Max.
Low Level Output Voltage	V_{OL}			0.4	V	I_{OL} = 3.2 mA
Rise Time	t_r		0.5		μs	C_L = 25 pF, R_L = 11K Pull-up
Fall Time	t_f		0.2			See Note 6
Cable Capacitance	C_{CO}		12		pF/meter	Output Lead to Ground

NOTES:

1. The structural parts of the HEDS-6000 have been successfully tested to 20g. In a high vibration environment use is limited at low frequencies (high displacement) by cable fatigue and at high frequencies by code wheel resonances. Resonant frequency depends on code wheel material and number of counts per revolution. For temperatures below -20° C the ribbon cable becomes brittle and sensitive to displacements. Maximum operating and storage temperature includes the surface area of the encoder mounting. Consult factory for further information. See Application Note 1011.
2. In a properly assembled lot 99% of the units, when run at 25° C and 8 KHz, should exhibit a pulse width error less than 32 electrical degrees, and a state width error less than 40 electrical degrees. To calculate errors at other speeds and temperatures add the values specified in Figures 1 or 2 to the typical values specified under encoding characteristics or to the maximum 99% values specified in this note.
3. In a properly assembled lot, 99% of the units when run at 25° C and 8 KHz should exhibit an index pulse width greater than 260 electrical degrees and less than 460 electrical degrees. To calculate index pulse widths at other speeds and temperatures add the values specified in Figures 3 or 4 to the typical 360° pulse width or to the maximum 99% values specified in this note.
4. Index phase is adjusted at assembly. Index phase error is the maximum change in index phase expected over the full temperature range and up to 50 KHz, after assembly adjustment of the index pulse position has been made.
5. When the index pulse is centered on the low-low states of channels A and B as shown on page 2, a unique P_O can be defined once per revolution within the recommended operating conditions and up to 25 KHz. Figure 6 shows how P_O can be derived from A, B, and I outputs. The adjustment range indicates how far from the center of the low-low state that the center of the index pulse may be adjusted.
6. The rise time is primarily a function of the RC time constant of R_L and C_L. A faster rise time can be achieved with either a lower value of R_L or C_L. Care must be observed not to exceed the recommended value of I_{OL} under worst case conditions.

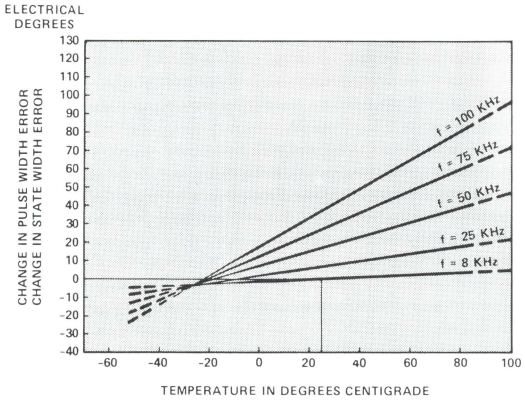


Figure 1. Typical Change in Pulse Width Error or in State Width Error due to Speed and Temperature

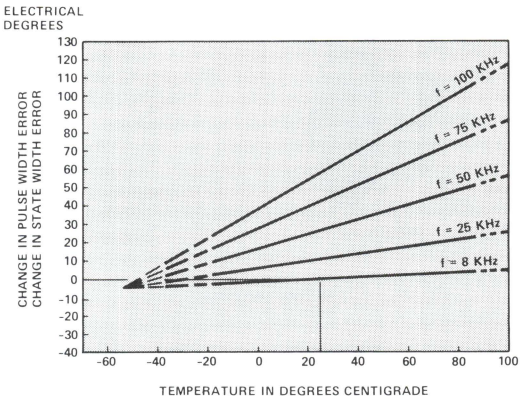


Figure 2. Maximum Change in Pulse Width Error or in State Width Error Due to Speed and Temperature

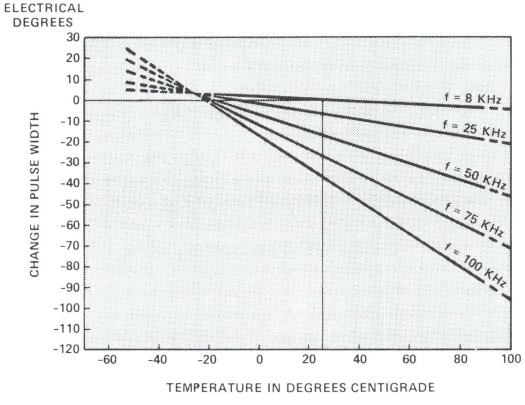


Figure 3. Typical Change in Index Pulse Width Due to Speed and Temperature

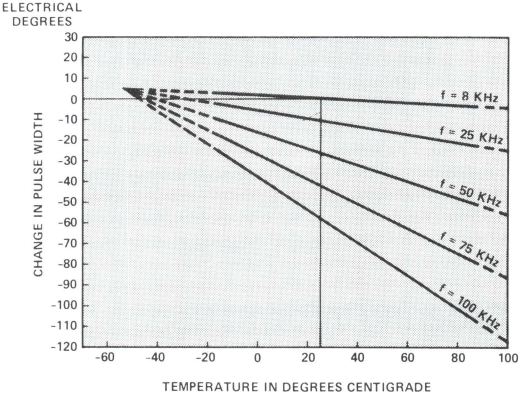


Figure 4. Maximum Change in Index Pulse Width Due to Speed and Temperature

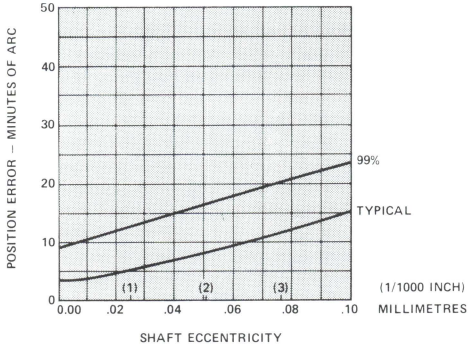
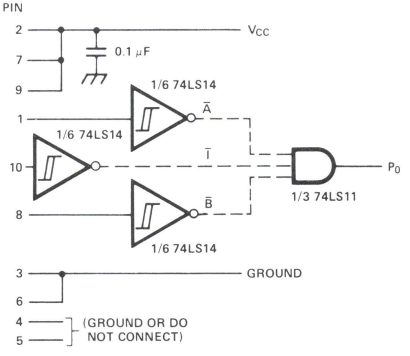


Figure 5. Position Error vs. Shaft Eccentricity



DASHED LINES REPRESENT AN OPTIONAL INDEX SUMMING CIRCUIT.
STANDARD 74 SERIES COULD ALSO BE USED TO IMPLEMENT THIS CIRCUIT.

Figure 6. Recommended Interface Circuit

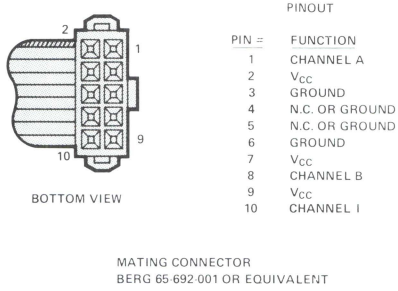


Figure 7. Connector Specifications

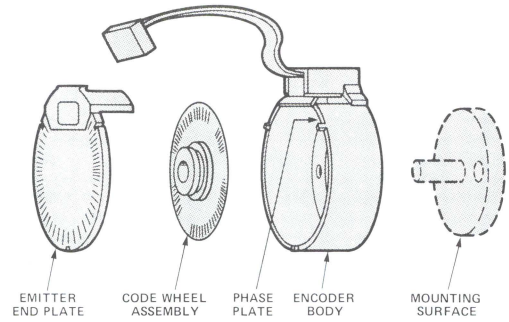


Figure 8. HEDS-6000 Series Encoder Kit

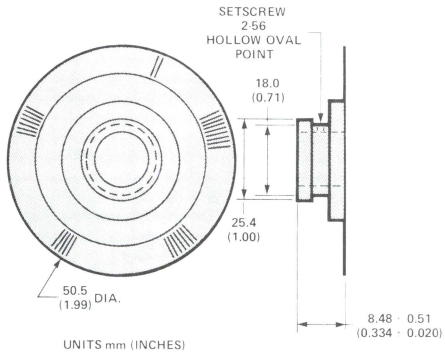


Figure 9. Code Wheel

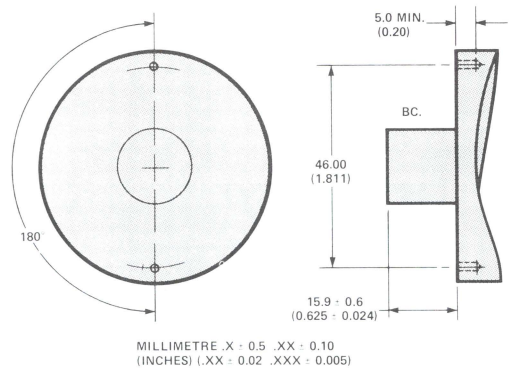
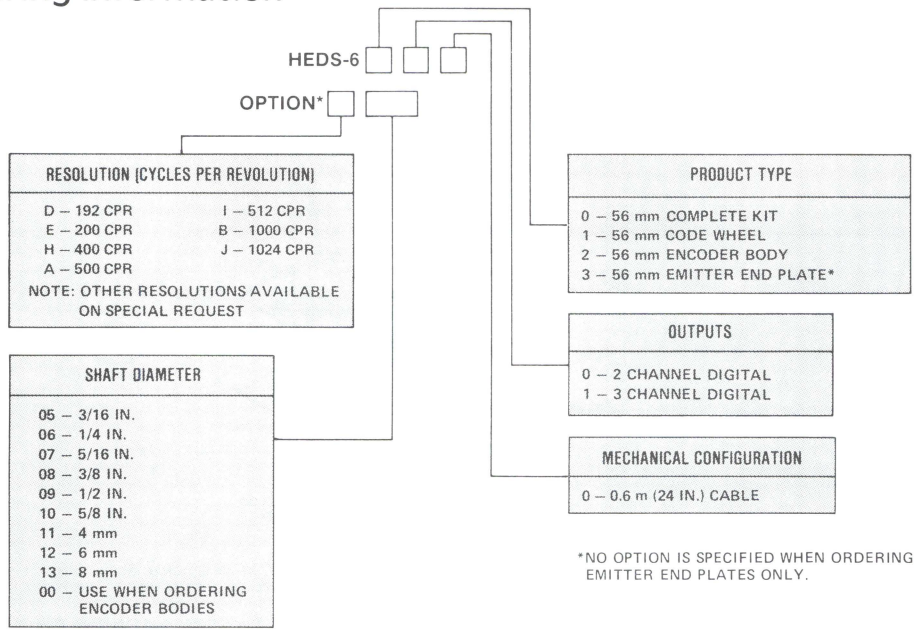


Figure 10. Mounting Requirements

Ordering Information



Shaft Encoder Kit Assembly **See Application Note 1011 for further discussion.**

The following assembly procedure represents a simple and reliable method for prototype encoder assembly. High volume assembly may suggest modifications to this procedure using custom designed tooling. In certain high volume applications encoder assembly can be accomplished in less than 30 seconds. Consult factory for further details. Note — the code wheel to phase plate gap should be set between 0.015 in. and 0.045 in.

WARNING: THE ADHESIVES USED MAY BE HARMFUL. CONSULT THE MANUFACTURER'S RECOMMENDATIONS.

READ THE INSTRUCTIONS TO THE END BEFORE STARTING ASSEMBLY.

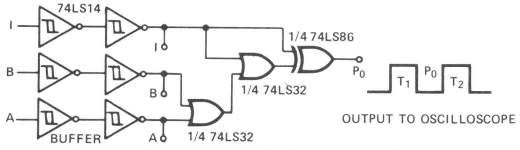
1.0 SUGGESTED MATERIALS

1.1 Encoder Parts
Encoder Body
Emitter End Plate
Code Wheel

1.2 Assembly Materials
RTV-General Electric 162
-Dow Corning 3145
Acetone
Mounting Screws (2)

1.3 Assembly Tools
a) Torque limiting screwdriver, 0.5 cm kg. (7.0 in. oz.).
b) Straight edge. Straight within 0.1 mm (0.004 in.)
c) Oscilloscope. (Phase meter may be optionally used for two channel calibration).
d) Hub puller. Grip-O-Matic-OTC #1000 2-jaw or equivalent. Optional tool for removing code wheels.
e) Syringe applicator for RTV.
f) Torque limiting Allen wrench. 0.5 cm kg (7.0 in. oz.) 0.035 in. hex.

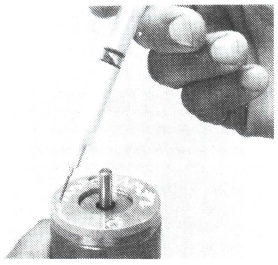
1.4 Suggested Circuits
a) Suggested circuit for index adjustment (HEDS-6010).



For optimal index phase adjust encoder position to equalize T_1 and T_2 pulse widths.

b) Phase Meter Circuit
Recommended for volume assembly. Please see Application Note 1011 for details.

2.0 SURFACE PREPARATION



THE ELAPSED TIME BETWEEN THIS STEP AND THE COMPLETION OF STEP 8 SHOULD NOT EXCEED 1/2 HOUR.

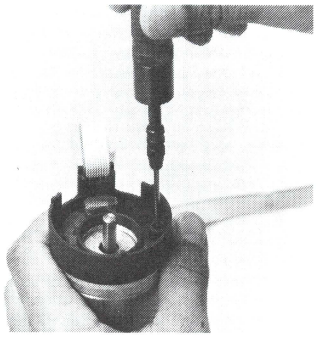
2.1 Clean and degrease with acetone the mounting surface and shaft making sure to keep the acetone away from the motor bearings.

2.2 Load the syringe with RTV.

2.3 Apply RTV into screw threads on mounting surface. Apply more RTV on the surface by forming a daisy ring pattern connecting the screw holes as shown above.

CAUTION: KEEP RTV AWAY FROM THE SHAFT BEARING.

3.0 ENCODER BODY ATTACHMENT



3.1 Place the encoder body on the mounting surface and slowly rotate the body to spread the adhesive. Align the mounting screw holes with the holes in the body base.

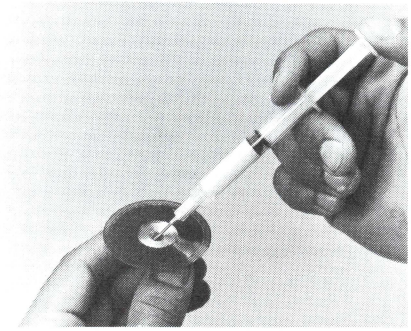
3.2 Place the two mounting screws into the holding bosses in the body base, as shown.

3.3 Thread the screws into the mounting holes and tighten both to 0.5 cm kg (7.0 in. oz.) using the torque limiting screwdriver. (See notes A and B).

3.4 It is not necessary to center the encoder body at this time.

Notes:
a) At this torque value, the encoder body should slide on the mounting surface only with considerable thumb pressure.
b) The torque limiting screwdriver should be periodically calibrated for proper torque.

4.0 APPLICATION OF RTV TO THE HUB



CAUTION: HANDLE THE CODE WHEEL WITH CARE.

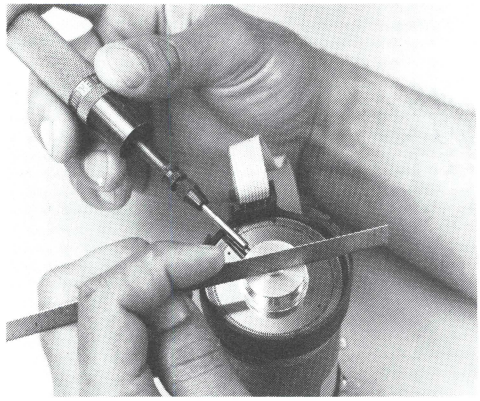
4.1 Make sure that the hex screw on the hub does not enter into the hub bore.

4.2 Apply a small amount of RTV onto the inner surface of the hub bore.

4.3 Spread the RTV evenly inside the entire hub bore.

4.4 Holding the code wheel by its hub, slide it down onto the shaft until the shaft extends at least halfway into the bore.

5.0 CODE WHEEL POSITIONING



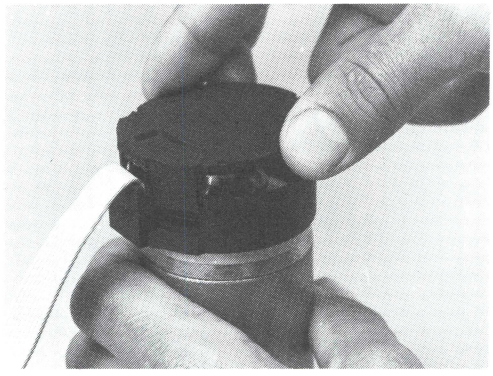
5.1 Position the Allen torque wrench into the hex set screw in the hub, as shown.

5.2 Pull the shaft end down to bottom out axial shaft play. Using the straight edge, push the top of the hub even with the top of the encoder body. The Allen wrench should be used during this movement to apply a slight upward force to the hub, insuring continuous contact between the straight edge and the hub.

5.3 Tighten the hex set screw to approximately 0.5 cm. kg. (7.0 in. oz.) and remove the straight edge.

5.4 The code wheel gap may now be visually inspected to check against gross errors. A nominal gap of 0.8 mm (0.030 in.) should be maintained.

6.0 EMITTER END PLATE

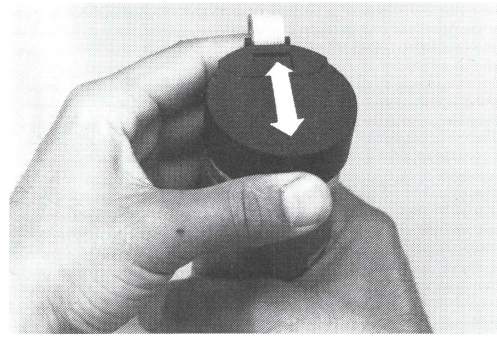


6.1 Visually check that the wire pins in the encoder body are straight and straighten if necessary.

6.2 Align the emitter end plate so that the two flanges straddle the track of the encoder body where the wire pins are located. Press the end plate until it snaps into place.

6.3 Visually check to see if the end plate is properly seated.

7.0 PHASE ADJUSTMENT



7.1 The following procedure should be followed when phase adjusting channels A and B.

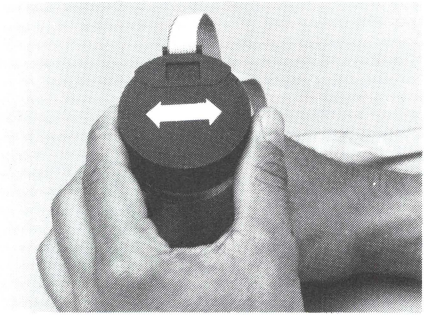
7.2 Connect the encoder cable.

7.3 Run the motor. Phase corresponds to motor direction. See output waveforms and definitions. Using either an oscilloscope or a phase meter, adjust the encoder for minimum phase error by sliding the encoder forward or backward on the mounting surface as shown above. See Application Note 1011 for the phase meter circuit.

7.4 No stress should be applied to the encoder package until the RTV cures. Curve time is 2 hours @ 70° C or 24 hours at room temperature.

Note: After mounting, the encoder should be free from mechanical forces that could cause a shift in the encoder's position relative to its mounting surface.

8.0 INDEX PULSE ADJUSTMENT (HEDS-6010)



8.1 Some applications require that the index pulse be aligned with the main data channels. The index pulse position and the phase must be adjusted simultaneously. This procedure sets index phase to zero.

8.2 Connect the encoder cable.

8.3 Run the motor. Adjust for minimum phase error using an oscilloscope or phase meter. (See 7.3).

8.4 Using an oscilloscope and the circuit shown in 1.4, set the trigger for the falling edge of the P_1 output. Adjust the index pulse so that T_1 and T_2 are equal in width. The physical adjustment is a side to side motion as shown by the arrow.

8.5 Recheck the phase adjustment.

8.6 Repeat steps 8.3-8.5 until both phase and index pulse position are as desired.

8.7 No stress should be applied to the encoder package until the RTV has cured. Cure time: 2 hours @ 70° C or 24 hours at room temperature.

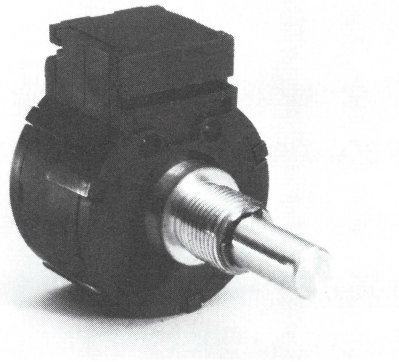
HEWLETT PACKARD

PANEL MOUNT DIGITAL POTENTIOMETER

HEDS-7500 SERIES

Features

- **DESIGNED FOR MANUAL OPERATION**
- **SMALL SIZE**
- **RELIABLE OPTICAL TECHNOLOGY**
- **256 PULSES PER REVOLUTION STANDARD Other Resolutions Available**
- **TTL COMPATIBLE DIGITAL OUTPUT**
- **SINGLE 5 V SUPPLY**
- **—20° TO +85° C OPERATING RANGE**
- **0.1 OZ.-IN. NOMINAL SHAFT TORQUE**



Description

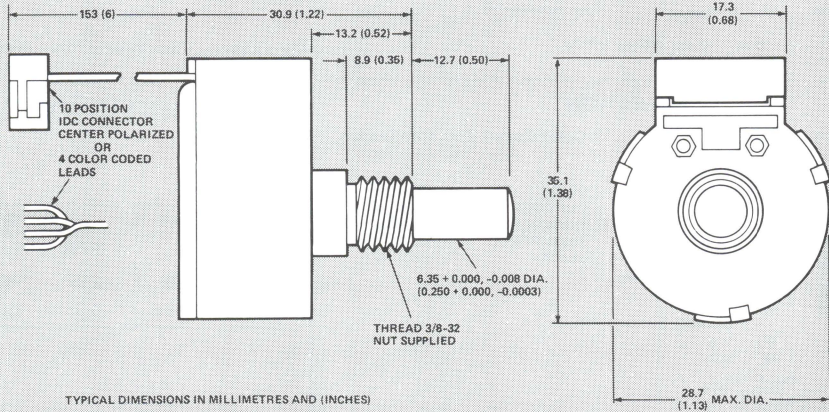
The HEDS-7500 series is a family of digital potentiometers designed for applications where a hand operated panel mounted encoder is required. The unit outputs two digital waveforms which are 90 degrees out of phase to provide resolution and direction information. 256 pulses per revolution is available as a standard resolution. The digital outputs and the 5 V supply input of the HEDS-7500 are accessed through color coded wire or through a 10 pin connector mounted on a 6 inch ribbon cable. Each digital output is capable of driving two standard TTL loads.

The HEDS-7500 emphasizes reliability by using solid state LEDs and photodiode detectors. A non-contacting slotted code wheel rotates between the LED and detector to provide digital pulses without wipers or noise. The HEDS-7500 is configured to provide standard potentiometer type panel mounting. Additional design information is available in Application Note 1025.

Applications

The HEDS-7500 series digital potentiometer may be used in applications where a manually operated knob is required to convert angular position into digital information.

Outline Drawing



MOTION SENSING AND CONTROL

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	-40	+85	°C	
Operating Temperature	T_A	-40	+85	°C	
Vibration			20	g	20 Hz - 2 kHz
Shock			30	g	11 msec
Supply Voltage	V_{CC}	-0.5	7	V	
Output Voltage	V_O	-0.5	V_{CC}	V	
Output Current per Channel	I_O	-1	5	mA	
Shaft Load — Radial Axial			1 1	lbs. lbs.	

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Notes
Temperature	T	-20	85	°C	Non-condensing atmosphere
Supply Voltage	V_{CC}	4.5	5.5	V	Ripple < 100 mV_{p-p}
Rotation Speed			300	RPM	

Electrical Characteristics

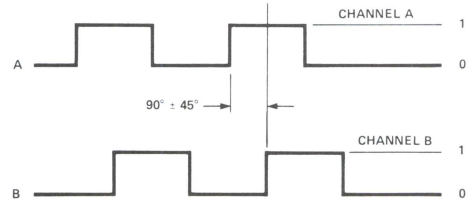
When operating within the recommended operating range.

Electrical Characteristics Over Recommended Operating Range Typical at 25° C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}		21	40	mA	
High Level Output Voltage	V_{OH}	2.4			V	I_{OH} = -40 μA Max.
Low Level Output Voltage	V_{OL}			0.4	V	I_{OL} = 3.2 mA

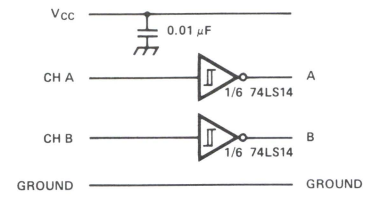
CAUTION: Device not intended for applications where coupling to a motor is required.

WAVEFORMS



CH B LEADS CH A FOR COUNTERCLOCKWISE ROTATION.
CH A LEADS CH B FOR CLOCKWISE ROTATION.

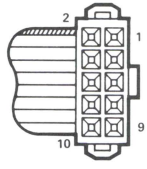
RECOMMENDED INTERFACE CIRCUIT



STANDARD 74 SERIES COULD ALSO BE USED TO IMPLEMENT THIS CIRCUIT.

TERMINATION

Ribbon Cable Termination



BOTTOM VIEW

PINOUT

PIN #	FUNCTION
1	CHANNEL A
2	V_{CC}
3	GROUND
4	N.C. OR GROUND
5	N.C. OR GROUND
6	GROUND
7	V_{CC}
8	CHANNEL B
9	V_{CC}
10	N.C.

NOTE: REVERSE INSERTION OF THE CONNECTOR WILL PERMANENTLY DAMAGE THE DETECTOR IC.

MATING CONNECTOR
BERG 65-692-001 OR EQUIVALENT

Color Coded Wire Termination

COLOR	DESIGNATION
WHITE/BLACK/RED	CHANNEL A
WHITE/BLACK/BROWN	CHANNEL B
WHITE/RED	V_{CC}
BLACK	GROUND

Ordering Information

Part Number	Description	
	PPR	Termination
HEDS-7500	256	Wire
HEDS-7501	256	Cable

HEWLETT PACKARD

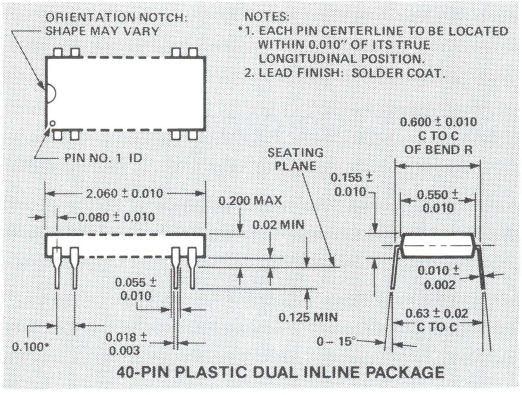
GENERAL PURPOSE MOTION CONTROL IC

HCTL-1000

Features

- DC, DC BRUSHLESS AND STEPPER MOTOR CONTROL
- POSITION CONTROL
- VELOCITY CONTROL
- PROGRAMMABLE VELOCITY PROFILING
- PROGRAMMABLE DIGITAL FILTER
- PROGRAMMABLE COMMUTATOR
- PROGRAMMABLE PHASE OVERLAP
- PROGRAMMABLE PHASE ADVANCE
- GENERAL 8 BIT PARALLEL I/O PORT
- 8 BIT PARALLEL MOTOR COMMAND PORT
- PWM MOTOR COMMAND PORT
- QUADRATURE DECODER FOR ENCODER SIGNALS
- 24 BIT POSITION COUNTER
- SINGLE 5 V POWER SUPPLY
- TTL COMPATIBLE
- 1 OR 2 MHz CLOCK OPERATION

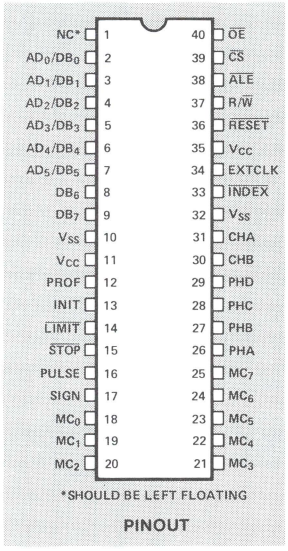
Package Dimensions



40-PIN PLASTIC DUAL INLINE PACKAGE

General Description

The HCTL-1000 is a high performance, general purpose motion control IC fabricated in Hewlett-Packard NMOS technology. It performs all the time-intensive tasks of digital motion control, thereby freeing the host processor for other tasks. The simple programmability of all control parameters provides the user with maximum flexibility and quick design of control systems with a minimum number of components. All that is needed for a complete servo system is a host processor to specify commands, an amplifier and motor with an incremental encoder. No analog compensation or velocity feedback is necessary (see Figure 1).



*SHOULD BE LEFT FLOATING

PINOUT

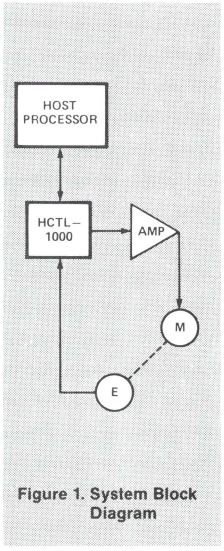


Figure 1. System Block Diagram

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DC Characteristics	3
AC Characteristics	4
Timing Diagrams	5
Functional Pin Description	9
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— User Accessible Registers	10
— Operating Modes	13
— Commutator	17
Interfacing the HCTL-1000	20
— I/O Interface	20
— Encoder Interface	20
— Amplifier Interface	21

ESD WARNING: Since this is an NMOS device, normal precautions should be taken to avoid static damage.

MOTION SENSING AND CONTROL

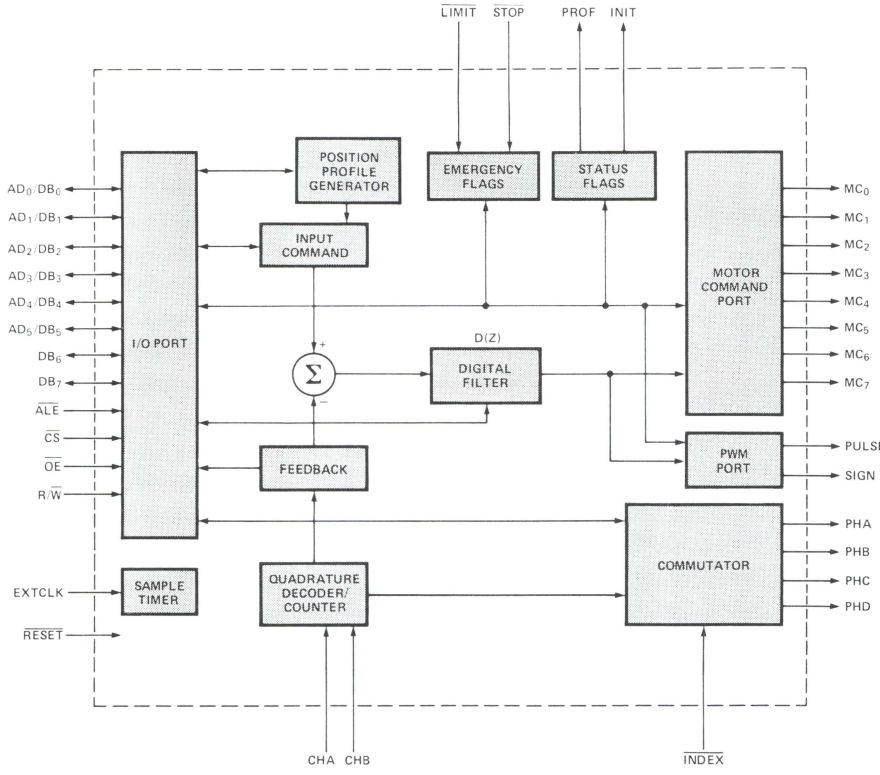


Figure 2. Internal Block Diagram

Introduction

The purpose of this section is to describe the organization of this data sheet. The front page includes the key features of the HCTL-1000, a general description of the part, the mechanical drawing and pin-out, and a Table of Contents. Following this section is the Theory of Operation, which gives the user a brief overview of how the HCTL-1000 operates by describing the internal block diagram shown in Figure 2. The following five sections give the specifications of the HCTL-1000, including Absolute Maximum Ratings, DC Characteristics, AC Characteristics, Timing Diagrams, and Functional Pin Descriptions. The final two sections include the detailed information on how to operate and interface to the HCTL-1000. The How to Operate section discusses the function and address of each software register, and describes how to use the four position and velocity control modes and the electronic commutator. The How to Interface section describes how to interface the HCTL-1000 to a microprocessor, an encoder, and an amplifier.

Theory of Operation

The HCTL-1000 is a general purpose motor controller which provides position and velocity control for dc, dc brushless and stepper motors. The internal block diagram of the HCTL-1000 is shown in Figure 2. The HCTL-1000 receives it input commands from a host processor and position feedback from an incremental encoder with quadrature output. An 8-bit directional multiplexed address/data bus interfaces the HCTL-1000 to the host processor. The encoder feedback is decoded into quadrature counts and a 24-bit counter keeps track of position. The HCTL-1000 executes any one of four control algorithms selected by the user. The four control modes are:

- Position Control
- Proportional Velocity Control
- Trapezoidal Profile Control for point to point moves
- Integral Velocity Control with continuous velocity profiling using linear acceleration

The resident Position Profile Generator calculates the necessary profiles for Trapezoidal Profile Control and Integral Velocity Control. The HCTL-1000 compares the desired position (or velocity) to the actual position (or velocity) to compute compensated motor commands using a programmable digital filter D(z). The motor command is externally available at the Motor Command port as an 8-bit byte and at the PWM port as a Pulse Width Modulated (PWM) signal.

The HCTL-1000 has the capability of providing electronic commutation for dc brushless and stepper motors. Using the encoder position information, the motor phases are enabled in the correct sequence. The commutator is fully programmable to encompass most motor encoder combinations. In addition, phase overlap and phase advance can be programmed to improve torque ripple and high speed performance. The HCTL-1000 contains a number of flags including two externally available flags, Profile and Initialization, which allow the user to see or check the status of the controller. It also has two emergency flags, $\overline{\text{Limit}}$ and $\overline{\text{Stop}}$, which allow operation of the HCTL-1000 to be interrupted under emergency conditions.

The HCTL-1000 controller is a digitally sampled data system. While information from the host processor is accepted asynchronously with respect to the control functions, the motor command is computed on a discrete sample time basis. The sample timer is programmable.

Absolute Maximum Ratings

Operating Temperature ..... 0°C to 70°C
Storage Temperature ..... -40°C to +125°C
Supply Voltage ..... -0.3 V to 7 V
Input Voltage ..... -0.3 V to 7 V
Maximum Power Dissipation ..... 0.95 W
Maximum Clock Frequency ..... 2 MHz

D.C. Characteristics $T_A = 0°C$ to $+70°C$; $V_{CC} = 5\ V \pm 5\%$; $V_{SS} = 0\ V$

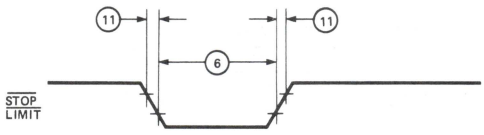
Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Power Supply	V_{CC}	4.75	5.00	5.25	V	
Supply Current	I_{CC}		80	180	mA	
Input Leakage Current	I_{il}			10	μA	$V_{IN} = 5.25\ V$
Tristate Output Leakage Current	I_{loh}			±10	μA	$V_{OUT} = -0.3$ to $5.25\ V$
Input Low Voltage	V_{IL}	-0.3		0.8	V	
Input High Voltage	V_{IH}	2.0		V_{CC}	V	
Output Low Voltage	V_{OL}	-0.3		0.4	V	$I_{OL} = 2.2\ mA$
Output High Voltage	V_{OH}	2.4		V_{CC}	V	$I_{OH} = -200\ \mu A$
Power Dissipation	P_D		400	950	mW	
Input Capacitance	C_{IN}			20	pF	$T_A = 25°C$, f = 1 MHz unmeasured pins returned to ground
Output Capacitance Load	C_{OUT}		100		pF	Same as above

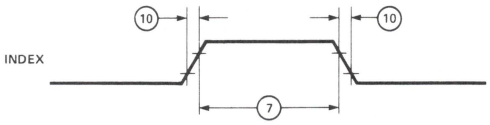
A.C. Electrical Characteristics T_A = 0° C to 70° C; V_{CC} = 5 V ± 5%; Units = nsec

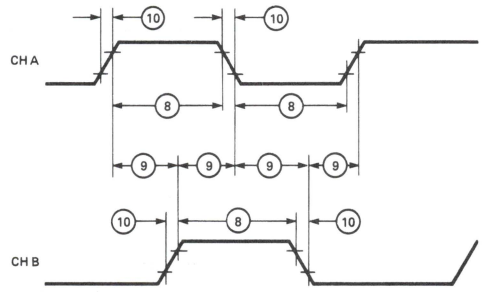
ID#	Signal	Symbol	Clock Frequency			
			2 MHz		1 MHz	
			Min.	Max.	Min.	Max.
1	Clock Period	t_{CPER}	500		1000	
2	Pulse Width, Clock High	t_{CPWH}	230		300	
3	Pulse Width, Clock Low	t_{CPWL}	200		200	
4	Clock Rise and Fall Time	t_{CR}		50		50
5	Input Pulse Width $\overline{\text{Reset}}$	t_{IRST}	2500		5000	
6	Input Pulse Width $\overline{\text{Stop}}$, $\overline{\text{Limit}}$	t_{IP}	600		1100	
7	Input Pulse Width $\overline{\text{Index}}$, Index	t_{IX}	1600		3100	
8	Input Pulse Width CHA, CHB	t_{IAB}	1600		3100	
9	Delay CHA to CHB Transition	t_{AB}	600		1100	
10	Input Rise/Fall Time CHA, CHB, Index	t_{IABR}		450		900
11	Input Rise/Fall Time $\overline{\text{Reset}}$, $\overline{\text{ALE}}$, $\overline{\text{CS}}$, $\overline{\text{OE}}$, $\overline{\text{Stop}}$, $\overline{\text{Limit}}$	t_{IR}		50		50
12	Input Pulse Width $\overline{\text{ALE}}$, $\overline{\text{CS}}$	t_{IPW}	80		80	
13	Delay Time, $\overline{\text{ALE}}$ Fall to $\overline{\text{CS}}$ Fall	t_{AC}	50		50	
14	Delay Time, $\overline{\text{ALE}}$ Rise to $\overline{\text{CS}}$ Rise	t_{CA}	50		50	
15	Address Set Up Time Before $\overline{\text{ALE}}$ Rise	t_{ASR1}	20		20	
16	Address Set Up Time Before $\overline{\text{CS}}$ Fall	t_{ASR}	20		20	
17	Write Data Set Up Time Before $\overline{\text{CS}}$ Rise	t_{DSR}	20		20	
18	Address/Data Hold Time	t_H	20		20	
19	Set Up Time, R/$\overline{\text{W}}$ Before $\overline{\text{CS}}$ Rise	t_{WCS}	20		20	
20	Hold Time, R/$\overline{\text{W}}$ After $\overline{\text{CS}}$ Rise	t_{WH}	20		20	
21	Delay Time, Write Cycle, $\overline{\text{CS}}$ Rise to $\overline{\text{ALE}}$ Fall	t_{CSAL}	1700		3400	
22	Delay Time, Read/Write, $\overline{\text{CS}}$ Rise to $\overline{\text{CS}}$ Fall	t_{CSCS}	1500		3000	
23	Write Cycle, $\overline{\text{ALE}}$ Fall to $\overline{\text{ALE}}$ Fall For Next Write	t_{WC}	1830		3530	
24	Delay time, $\overline{\text{CS}}$ Rise to $\overline{\text{OE}}$ Fall	t_{CSOE}	1700		3200	
25	Delay Time, $\overline{\text{OE}}$ Fall to Data Bus Valid	t_{OEDB}	100		100	
26	Delay Time, $\overline{\text{CS}}$ Rise to Data Bus Valid	t_{CSDB}	1800		3300	
27	Input Pulse Width $\overline{\text{OE}}$	t_{IPWOE}	100		100	
28	Hold Time, Data Held After $\overline{\text{OE}}$ Rise	t_{DOEH}	20		20	
29	Delay Time, Read Cycle, $\overline{\text{CS}}$ Rise to $\overline{\text{ALE}}$ Fall	t_{CSALR}	1820		3320	
30	Read Cycle, $\overline{\text{ALE}}$ Fall to $\overline{\text{ALE}}$ Fall For Next Read	t_{RC}	1950		3450	
31	Output Pulse Width, PROF, INIT, Pulse, Sign, PHA-PHD, MC Port	t_{OF}	500		1000	
32	Output Rise/Fall Time, PROF, INIT, Pulse, Sign PHA-PHD, MC Port	t_{OR}	20	150	20	150
33	Delay Time, Clock Rise to Output Rise	t_{EP}	20	300	20	300
34	Delay Time, $\overline{\text{CS}}$ Rising to MC Port Valid	t_{CSMC}		1600		3200
35	Hold Time, $\overline{\text{ALE}}$ High After $\overline{\text{CS}}$ Rise	t_{ALH}	100		100	
36	Pulse Width, $\overline{\text{ALE}}$ High	t_{ALPWH}	100		100	

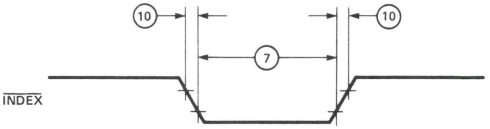
HCTL-1000 I/O Timing Diagrams

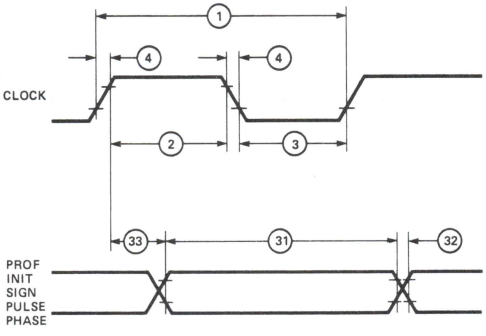
Input logic level values are the TTL Logic levels V_{IL} = 0.8 V and V_{IH} = 2.0 V.
Output logic levels are V_{OL} = 0.4 V and V_{OH} = 2.4 V.

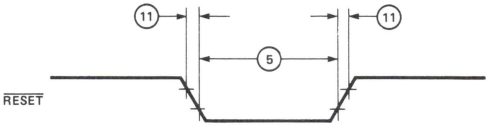










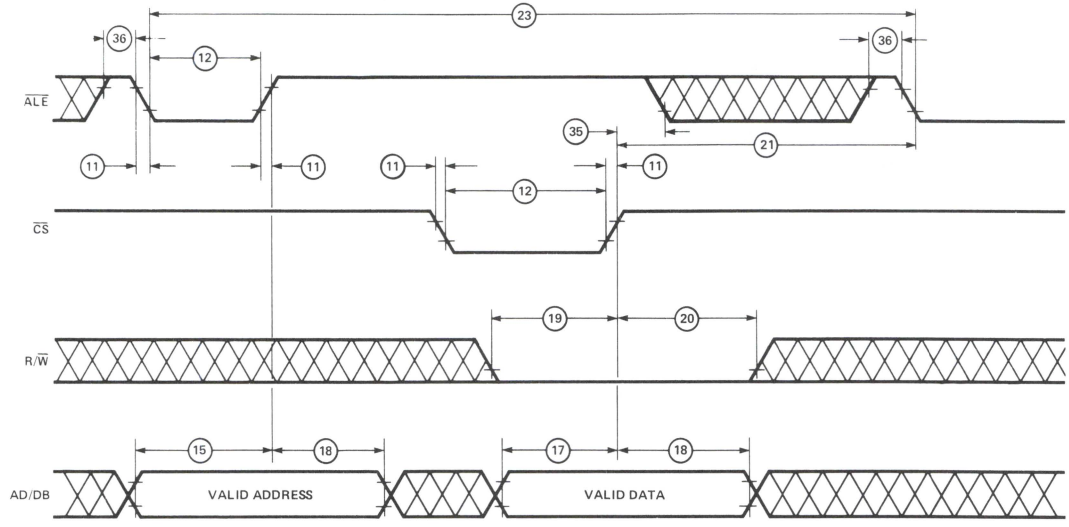


HCTL-1000 I/O Timing Diagrams

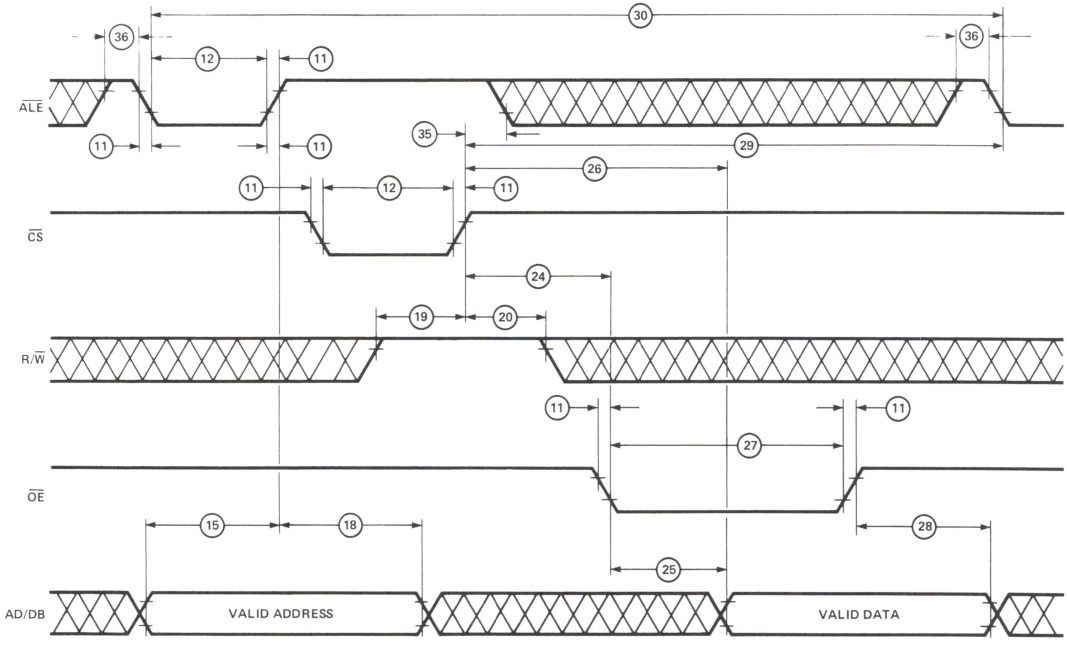
There are three different timing configurations which can be used to give the user flexibility to interface the HCTL-1000 to most microprocessors. See the I/O interface section for more details.

$\overline{ALE}/\overline{CS}$ NON OVERLAPPED

Write Cycle



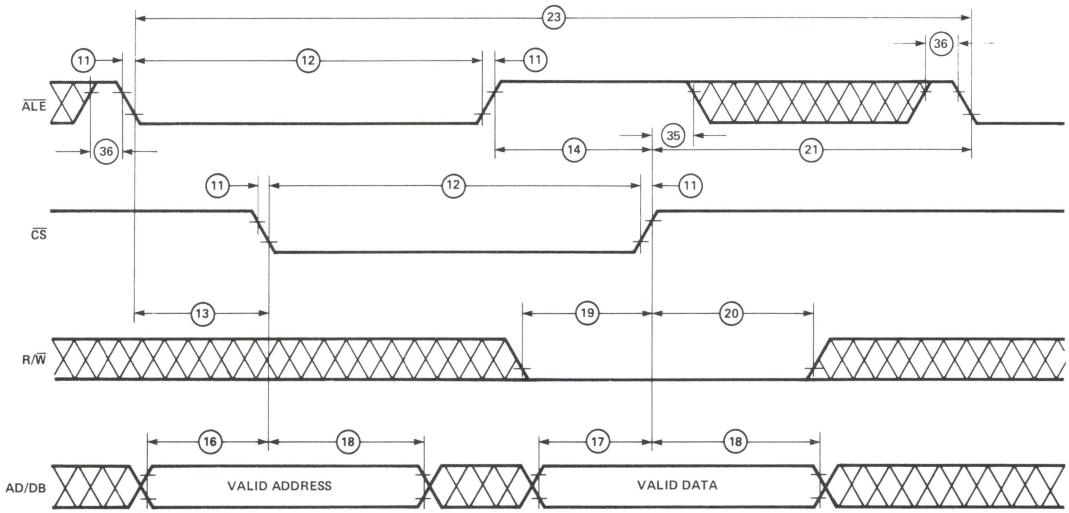
Read Cycle



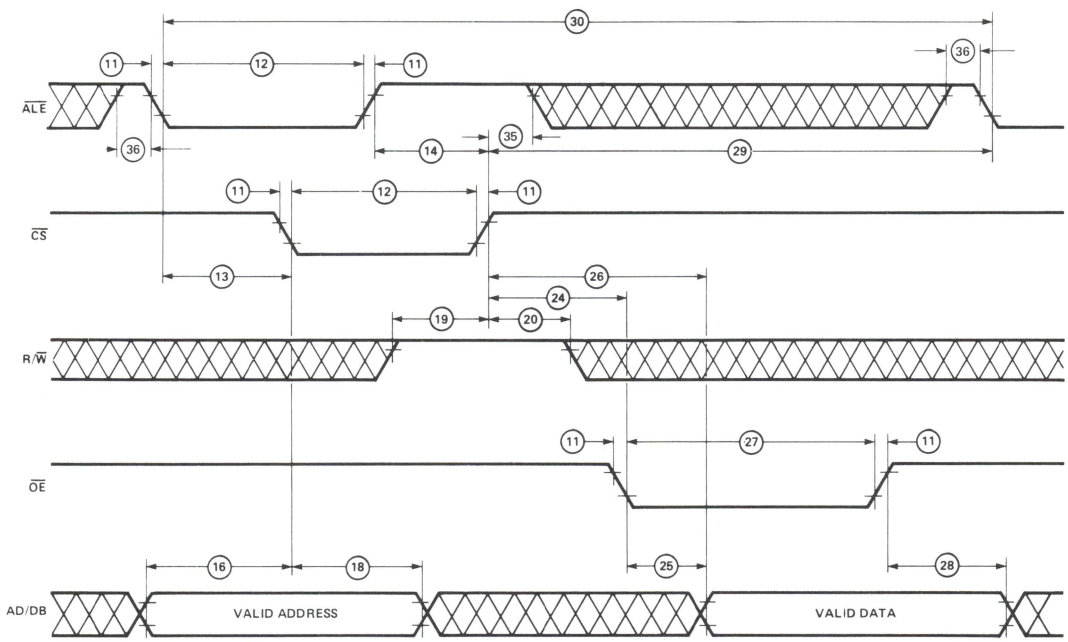
HCTL-1000 I/O Timing Diagrams

$\overline{ALE}$/$\overline{CS}$ OVERLAPPED

Write Cycle



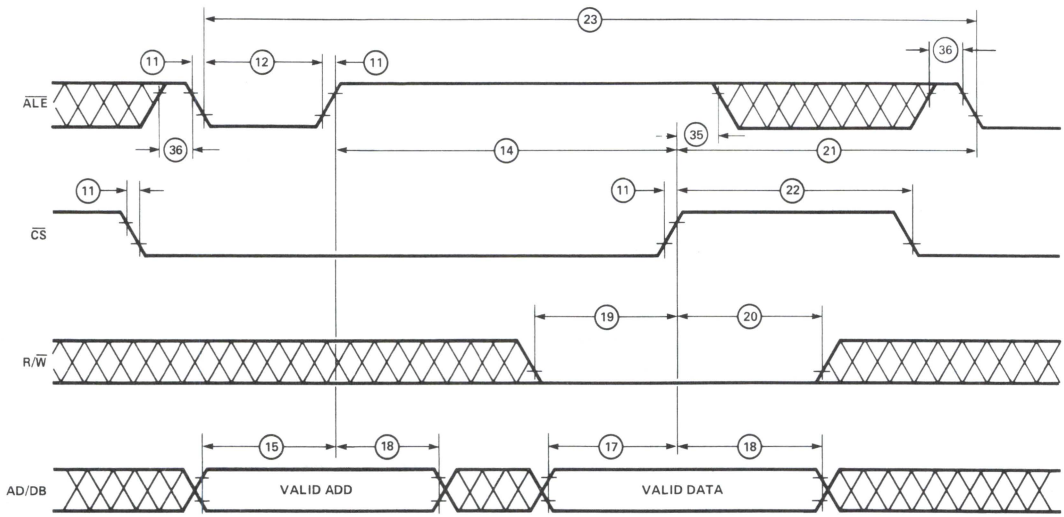
Read Cycle



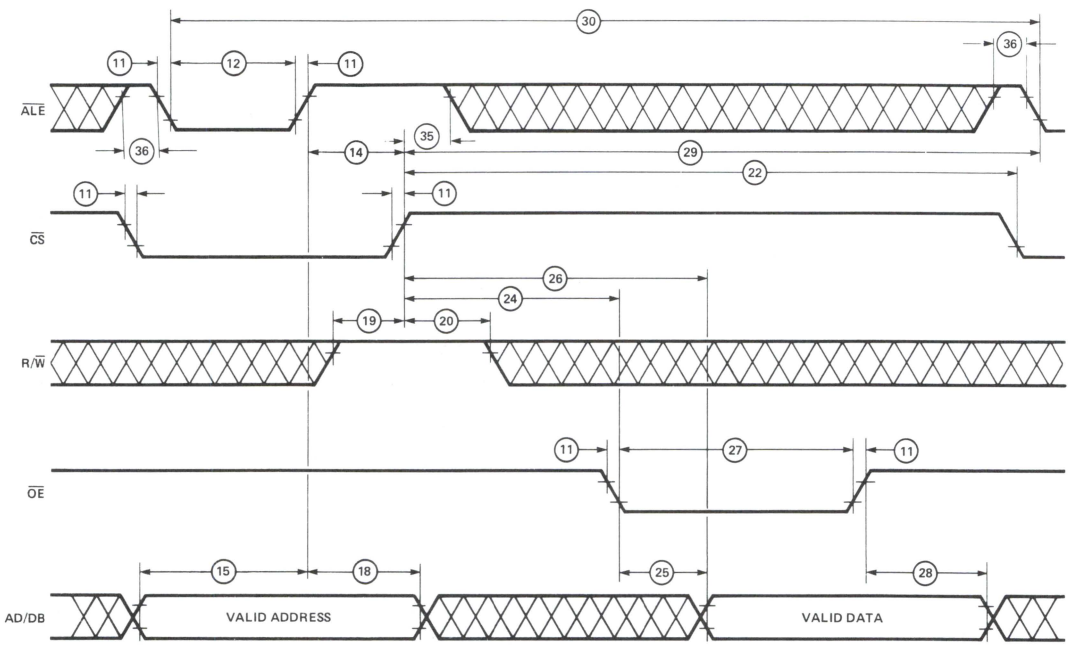
HCTL-1000 I/O Timing Diagrams

$\overline{ALE}$ WITHING $\overline{CS}$

Write Cycle



Read Cycle



Functional Pin Description

INPUT/OUTPUT SIGNALS

Symbol	Pin Number	Description
AD0/DB0-AD5/DB5	2-7	Address/Data bus — Lower 6 bits of 8-bit I/O port which are multiplexed between address and data.
D6, D7	8, 9	Data bus — Upper 2 bits of 8-bit I/O port used for data only.

INPUT SIGNALS

Symbol	Pin Number	Description
CHA/CHB	31, 30	Channel A,B — input pins for position feedback from an incremental shaft encoder. Two channels, A and B, 90 degrees out of phase are required.
$\overline{\text{Index}}$	33	Index Pulse — input from the reference or index pulse of an incremental encoder. Used only in conjunction with the Commutator. Either a low or high true signal can be used with the Index pin. See Timing Diagrams and Encoder Interface section for more detail.
R/$\overline{\text{W}}$	37	Read/Write — determines direction of data exchange for the I/O port.
$\overline{\text{ALE}}$	38	Address Latch Enable — enables lower 6 bits of external data bus into internal address latch.
$\overline{\text{CS}}$	39	Chip Select — performs I/O operation dependent on status of R/W line. For a Write, the external bus data is written into the internal addressed location. For Read, data is read from an internal location into an internal output latch.
$\overline{\text{OE}}$	40	Output Enable — enables the data in the internal output latch onto the external data bus to complete a Read operation.
$\overline{\text{Limit}}$	14	Limit Switch — an internal flag which when externally set, triggers an unconditional branch to the Initialization/Idle mode before the next control sample is executed. Motor Command is set to zero. Status of the Limit flag is monitored in the Status register.
$\overline{\text{Stop}}$	15	Stop Flag — an internal flag that is externally set. When flag is set during Integral Velocity Control mode, the Motor Command is decelerated to a stop.
$\overline{\text{Reset}}$	36	Reset — a hard reset of internal circuitry and a branch to Reset mode.
ExtClk	34	External Clock
V_{CC}	11, 35	Voltage Supply — Both V_{CC} pins must be connected to a 5.0 volt supply.
V_{SS}	10, 32	Circuit Ground
NC	1	Not Connected — this pin should be left floating.

OUTPUT SIGNALS

Symbol	Pin Number	Description
MC0-MC7	18-25	Motor Command Port — 8-bit output port which contains the digital motor command adjusted for easy bipolar DAC interfacing. MC7 is the most significant bit (MSB).
Pulse	16	Pulse — pulse width modulated signal whose duty cycle is proportional to the Motor Command magnitude. The frequency of the signal is External Clock/100 and pulse width is resolved into 100 external clocks.
Sign	17	Sign — gives the sign/direction of the pulse signal.
PHA-PHD	26-29	Phase A, B, C, D — Phase Enable outputs of the Commutator.
Prof	12	Profile Flag — Status flag which indicates that the controller is executing a profiled position move in the Trapezoidal Profile Control mode.
Init	13	Initialization/Idle Flag — Status flag which indicates that the controller is in the Initialization/Idle mode.

Operation of the HCTL-1000

USER ACCESSIBLE REGISTERS

The HCTL-1000 operation is controlled by a bank of 64 8-bit registers, 32 of which are user accessible. These registers contain command and configuration information necessary to properly run the controller chip. The 32 user-accessible registers are listed in Table I. The register number is also the address. A functional block diagram of the HCTL-1000 which shows the role of the user-accessible registers is also included in Figure 3. The other 32 registers are used by the internal CPU as scratch registers and should not be accessed by the user.

There are several registers which the user must configure to his application. These configuration registers are discussed in more detail below.

Program Counter (R05H)

The Program Counter, which is a write-only register, executes the preprogrammed functions of the controller. The program counter is used along with the control flags F0, F3, and F5 in the Flag register (R00H) to change control modes. The user can write any of the following four commands to the Program Counter.

00H — Software Reset
01H — Initialization/Idle mode
02H — Align mode
03H — Control modes; flags F0, F3, and F5 in the Flag register (R00H) specify which control mode will be executed.

The commands written to the Program Counter are discussed in more detail in the section called Operating Modes and are shown in flowchart form in Figure 4.

Flag Register (R00H)

The Flag register contains flags F0 thru F5. This register is also a *write-only register.* Each flag is set and cleared by writing an 8-bit data word to R00H. The upper four bits are ignored by the HCTL-1000. The bottom three bits specify the flag address and the fourth bit specifies whether to set (bit = 1) or clear (bit = 0) the addressed flag.

Bit number	7-4	3	2	1	0
Function	Don't care	set/clear	AD2	AD1	AD0

F0 — Trapezoidal Profile Flag — set by the user to execute Trapezoidal Profile Control. The flag is reset by the controller when the move is completed. The status of F0 can be monitored at the Profile pin (12) and in Status register R07H bit 4.

F1 — Initialization/Idle Flag — set/cleared by the HCTL-1000 to indicate execution of the Initialization/Idle mode. The status of F1 can be monitored at the Initialization/Idle pin (13) and in bit 5 of the Status register (R07H). The user should not attempt to set or clear F1.

F2 — Unipolar Flag — set/cleared by the user to specify Bipolar (clear) or Unipolar (set) mode for the Motor Command port.

F3 — Proportional Velocity Control Flag — set by the user to specify Proportional Velocity control.

F4 — Hold Commutator Flag — set/cleared by the user or automatically by the Align mode. When set, this flag inhibits the internal commutator counters to allow open loop stepping of a motor by using the commutator. (See "Offset register" description in the "Commutator section.")

F5 — Integral Velocity Control — set by the user to specify Integral Velocity Control. Also set and cleared by the HCTL-1000 during execution of the Trapezoidal Profile mode. This is transparent to the user except when the Limit flag is set (see "Emergency Flags" section).

Status Register (R07H)

The Status register indicates the status of the HCTL-1000. Each bit decodes into one signal. All 8 bits are user readable and are decoded as shown below. Only the lower 4 bits can be written to by the user to configure the HCTL-1000. To set or clear any of the lower 4 bits, the user writes an 8-bit word to R07H. The upper 4 bits are ignored. Each of the lower 4 bits directly sets/clears the corresponding bit of the Status register as shown below. For example, writing XXXX0101 to R07H sets the PWM Sign Reversal Inhibit, sets the Commutator Phase Configuration to "3 Phase", and sets the Commutator Count Configuration to "full".

Status Bit	Function	Note
0	PWM Sign Reversal Inhibit 0 = off 1 = on	Discussed in Amplifier Interface section under PWM Port.
1	Commutator Phase Configuration 0 = 3 phase 1 = 4 phase	Discussed in Commutator section
2	Commutator Count Configuration 0 = quadrature 1 = full	Discussed in Commutator section
3	Should always be set to 0	
4	Trapezoidal Profile Flag F0 1 = in Profile Control	Discussed in Operating Mode section under Trapezoidal Profile Control
5	Initialization/Idle Flag F1 1 = in Initialization/Idle Mode	Discussed in Operating Mode section under Initialization/Idle Mode
6	Stop Flag 0 = set (Stop triggered) 1 = cleared (no Stop)	Discussed in Emergency Flags section
7	Limit Flag 0 = set (Limit triggered) 1 = cleared (no Limit)	Discussed in Emergency Flags section

TABLE I: REGISTER REFERENCE TABLE

Register (Hex)	Register (Dec)	Function	Mode Used	Data Type[1]	User Access	Reference Page Number
R00H	R00D	Flag Register	All	—	w	10
R05H	R05D	Program Counter	All	scalar	w	10
R07H	R07D	Status Register	All	—	r/w[2]	10, 18
R08H	R08D	8 bit Motor Command Port	All	2's complement+80H	r/w	21
R09H	R09D	PWM Motor Command Port	All	2's complement	r/w	22
R0CH	R12D	Command Position (MSB)	All except Proportional Velocity	2's complement	r/w[3]	15
R0DH	R13D	Command Position	All except Proportional Velocity	2's complement	r/w[3]	15
R0EH	R14D	Command Position (LSB)	All except Proportional Velocity	2's complement	r/w[3]	15
R0FH	R15D	Sample Timer	All	scalar	w	13
R12H	R18D	Actual Position (MSB)	All	2's complement	r[4]	15
R13H	R19D	Actual Position	All	2's complement	r[4]/w[5]	15
R14H	R20D	Actual Position (LSB)	All	2's complement	r[4]	15
R18H	R24D	Commutator Ring	All	scalar[6,7]	r/w	18
R19H	R25D	Commutator Velocity Timer	All	scalar	w	19
R1AH	R26D	X	All	scalar[6]	r/w	18
R1BH	R27D	Y Phase Overlap	All	scalar[6]	r/w	18
R1CH	R28D	Offset	All	2's complement[7]	r/w	18
R1FH	R31D	Maximum Phase Advance	All	scalar[6, 7]	r/w	19
R20H	R32D	Filter Zero, A	All except Proportional Velocity	scalar	r/w	12
R21H	R33D	Filter Pole, B	All except Proportional Velocity	scalar	r/w	12
R22H	R34D	Gain, K	All	scalar	r/w	12
R23H	R35D	Command Velocity (LSB)	Proportional Velocity	2's complement	r/w	15
R24H	R36D	Command Velocity (MSB)	Proportional Velocity	2's complement	r/w	15
R26H	R38D	Acceleration (LSB)	Integral Velocity and Trapezoidal Profile	scalar	r/w	15, 16
R27H	R39D	Acceleration (MSB)	Integral Velocity and Trapezoidal Profile	scalar[6]	r/w	15, 16
R28H	R40D	Maximum Velocity	Trapezoidal Profile	scalar[6]	r/w	16
R29H	R41D	Final Position (LSB)	Trapezoidal Profile	2's complement	r/w	16
R2AH	R42D	Final Position	Trapezoidal Profile	2's complement	r/w	16
R2BH	R43D	Final Position (MSB)	Trapezoidal Profile	2's complement	r/w	16
R34H	R52D	Actual Velocity (LSB)	Proportional Velocity	2's complement	r	15
R35H	R53D	Actual Velocity (MSB)	Proportional Velocity	2's complement	r	15
R3CH	R60D	Command Velocity	Integral Velocity	2's complement	r/w	15

Notes:
1. Consult appropriate section for data format and use.
2. Upper 4 bits are read only.
3. Writing to R0EH (LSB) latches all 24 bits.
4. Reading R14H (LSB) latches data into R12H and R13H.
5. Writing to R13H clears Actual Position Counter to zero.
6. The scalar data is limited to positive numbers (00H to 7FH).
7. The commutator registers (R18H, R1CH, R1FH) have further limits which are discussed in the Commutator section of this data sheet.

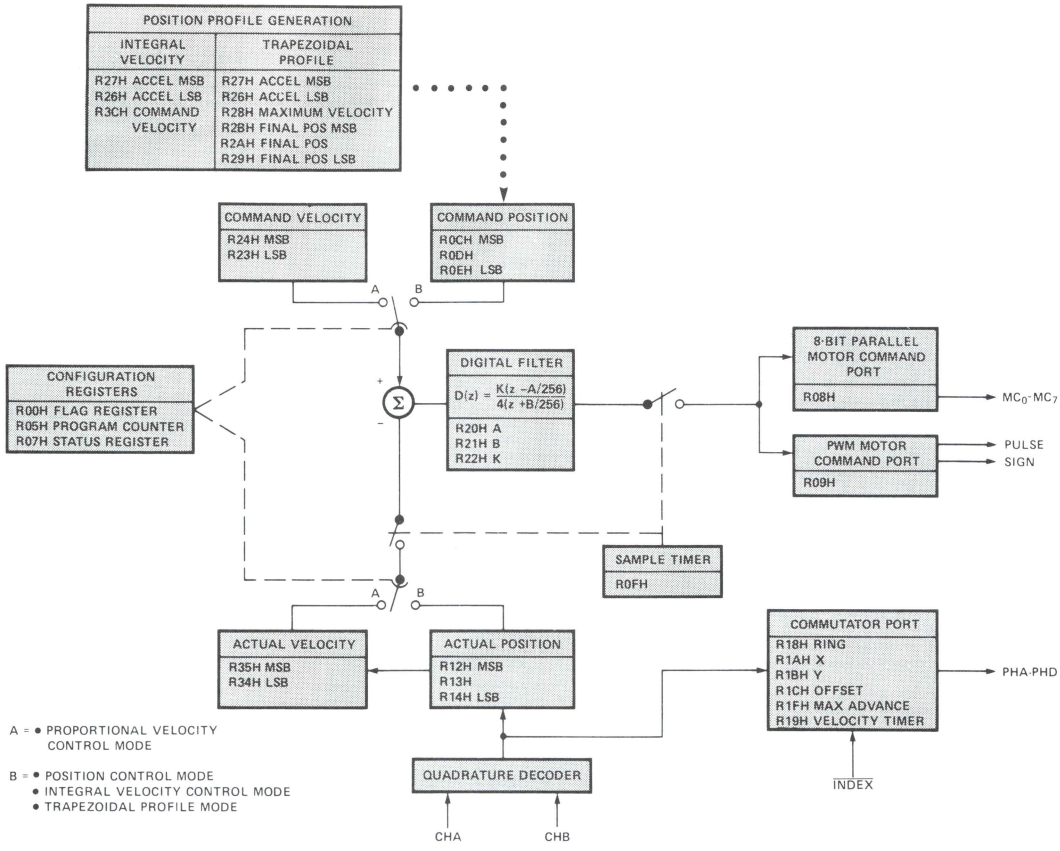


Figure 3. Register Block Diagram

Emergency Flags — Stop and Limit

Stop and Limit flags are hardware set flags that signify the occurrence of an emergency condition and cause the controller to immediately take special action.

The Stop flag affects the HCTL-1000 only in the Integral Velocity mode. When the Stop flag is set, the system will come to a decelerated stop and stay in this mode with a command velocity of zero until the Stop flag is cleared and a new command velocity is specified.

The Limit flag, when set in any control mode, causes the HCTL-1000 to go into the Initialization/Idle mode, clearing the Motor Command and causing an immediate motor shutdown. When the Limit flag is set, none of the three control mode flags (F0, F3, or F5) are cleared as the HCTL-1000 enters the Initialization/Idle mode. The user should be aware that these flags are still set before commanding the HCTL-1000 to re-enter one of the four control modes from Initialization/Idle mode. In addition, the user should note that if the Limit flag is set while the HCTL-1000 is in Trapezoidal Profile Control mode, then BOTH flags F0 AND F5 should be cleared before the HCTL-1000 is commanded to re-enter any of the four control modes from Initialization/Idle mode.

Stop and Limit flags are set by a low level input at their respective pins (15, 14). The flags can only be cleared when the input to the corresponding pin goes high, signifying that the emergency condition has been corrected, AND a write to the Status register (R07H) is executed. That is, after the emergency pin has been set and cleared, the flag also must be cleared by writing to R07H. Any word that is written to R07H after the emergency pin is set and cleared will clear the emergency flag, but the lower 4 bits of that word will also reconfigure the Status register.

Digital Filter (R22H, R20H, R21H)

All control modes use some part of the programmable digital filter D(z) to compensate for closed loop system stability. The compensation D(z) has the form:

$$D(z) = \frac{K\left(z - \frac{A}{256}\right)}{4\left(z + \frac{B}{256}\right)} \quad [1]$$

where:
z = the digital domain operator
K = digital filter gain (R22H)
A = digital filter zero (R20H)
B = digital filter pole (R21H)

The compensation is a first-order lead filter which in combination with the Sample Timer T(R0FH) affects the dynamic step response and stability of the control system. The Sample Timer, T, determines the rate at which the control algorithm gets executed. All parameters, A, B, K, and T, are 8-bit scalars that can be changed by the user any time.

The digital filter uses previously sampled data to calculate D(z). This old internally sampled data is cleared when the Initialization/Idle mode is executed.

In Position Control, Integral Velocity Control, and Trapezoidal Profile Control the digital filter is implemented in the time domain as shown below:

$$MC_n = (K/4)(X_n) - [(A/256)(K/4)(X_{n-1}) + (B/256)(MC_{n-1})] \quad [2]$$

where:

n = current sample time
n-1 = previous sample time
MC_n = Motor Command Output at n
MC_{n-1} = Motor Command Output at n-1
X_n = (Command Position - Actual Position) at n
X_{n-1} = (Command Position - Actual Position) at n-1

In Proportional Velocity control the digital compensation filter is implemented in the time domain as:

$$MC_n = (K/4)(Y_n) \quad [3]$$

where:

Y_n = (Command Velocity - Actual Velocity) at n

Sample Timer Register (R0FH)

The contents of this register set the sampling period of the HCTL-1000. The sampling period is:

$$t = 16(T+1)(1/\text{frequency of the external clock}) \quad [4]$$

where: T = register R0FH

The Sample Timer has a limit on the minimum allowable sample time depending on the control mode being executed. The limits are given below:

	R0FH Contents Minimum Limit
Position Control	07H (07D)
Proportional Velocity Control	07H (07D)
Trapezoidal Profile Control	0FH (15D)
Integral Velocity Control	0FH (15D)

The maximum value of T (R0FH) is FFH (255D). With a 2 MHz clock, the sample time can vary from 64 μsec to 2048 μsec. With a 1MHz clock, the sample time can vary from 128 μsec to 4096 μsec.

Digital closed-loop systems with slow sampling times have lower stability and a lower bandwidth than similar systems with faster sampling times. To keep the system stability and bandwidth as high as possible the HCTL-1000 should typically be programmed with the fastest sampling time possible.

The exception to this rule occurs when the user would like to use the HCTL-1000 to control a motor with an encoder at very slow velocities.

Velocities are specified to the HCTL-1000 in terms of quadrature encoder counts per sample time. In the Trapezoidal Profile and Integral Velocity Control modes, the minimum velocity which may be specified is one encoder count per sample time. The Proportional Velocity Control mode, allows a minimum velocity of 1 encoder count per 16 sample times to be specified. To achieve the slowest velocities possible, the sample times for the HCTL-1000 must be made as slow as possible.

For more information on system sampling times, bandwidth, and stability, please consult Hewlett-Packard Application Note 1032, "Design of the HCTL-1000's Digital Filter Parameters by the Combination Method."

OPERATING MODES

The HCTL-1000 executes any one of 3 set up routines or 4 control modes selected by the user. The 3 set up routines include:

— Reset
— Initialization/Idle
— Align.

The four control modes available to the user include:

— Position Control
— Proportional Velocity Control
— Trapezoidal Profile Control
— Integral Velocity Control

The HCTL-1000 switches from one mode to another as a result of one of the following three mechanisms:

1. The user writes to the Program Counter.
2. The user sets/clears flags F0, F3, or F5 by writing to the Flag register (R00H).
3. The controller switches automatically when certain initial conditions are provided by the user.

This section describes the function of each set up routine and control mode and the initial conditions which must be provided by the user to switch from one mode to another. Figure 4 shows a flowchart of the set up routines and control modes, and shows the commands required to switch from one mode to another.

Set Up Routines

1. RESET

The Reset mode is entered under all conditions by either executing a hard reset (Reset pin goes low) or a soft reset (write 00H to the Program Counter, R05H).

When a hard reset is executed, the following conditions occur:

— All output signal pins are held low except Sign (17). Databus (2-9), and Motor Command (18-25).
— All flags (F0 to F5) are cleared.
— The Pulse pin of the PWM port is set low while the $\overline{\text{Reset}}$ pin is held low. After the $\overline{\text{Reset}}$ pin is released (goes high) the Pulse pin goes high for one cycle of the external clock driving the HCTL-1000. The Pulse pin then returns to a low output.
— The Motor Command port (R08H) is preset to 80H. (128D)
— The Commutator logic is cleared.
— The I/O control logic is cleared.
— A soft reset is automatically executed.

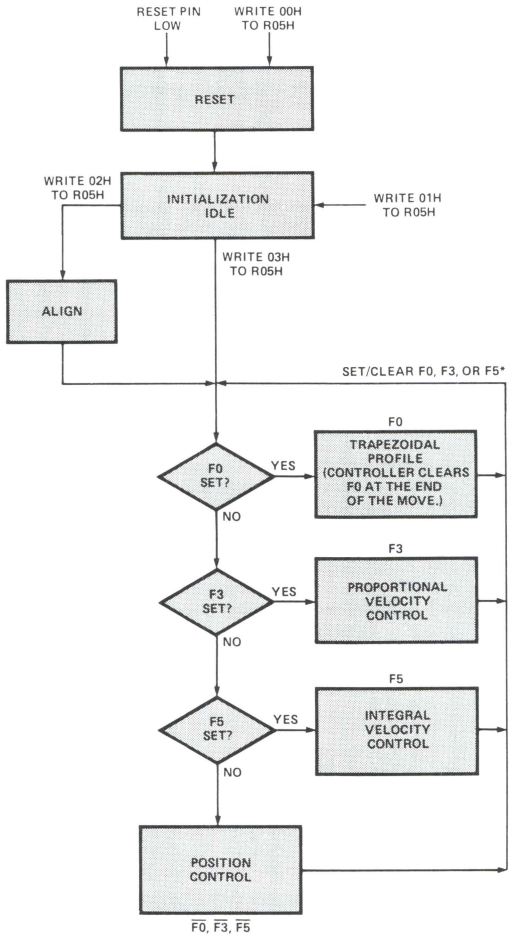
When a soft reset is executed, the following conditions occur:

— The digital filter parameters are preset to

A (R20H) = E5H (229D)
B (R21H) = K (R22H) = 40H (64D)

— The Sample Timer (R0FH) is preset to 40H. (64D)
— The Status register (R07H) is cleared.
— The Actual Position Counters (R12H, R13H, R14H) are cleared to 0.

From Reset mode, the HCTL-1000 goes automatically to Initialization/Idle mode.



*Only one flag can be set at a time.

Figure 4. Operating Mode Flowchart

2. INITIALIZATION/IDLE

The Initialization/Idle mode is entered either automatically from Reset, by writing 01H to the Program Counter (R05H) under any conditions, or pulling the Limit pin low.

In the Initialization/Idle mode, the following occur:

— The Initialization/Idle flag (F1) is set.
— The PWM port R09H is set to 00H (zero command).
— The Motor Command port (R08H) is set to 80H (128D) (zero command).
— Previously sampled data stored in the digital filter is cleared.

It is at this point that the user should pre-program all the necessary registers needed to execute the desired control mode. The HCTL-1000 stays in this mode (idling) until a new mode command is given.

3. ALIGN

The Align mode is executed only when using the commutator feature of the HCTL-1000. This mode automatically aligns multiphase motors to the HCTL-1000's internal Commutator.

The Align mode can be entered only from the Initialization/Idle mode by writing 02H to the Program Counter register (R05H). Before attempting to enter the Align mode, the user should clear all control mode flags and set both the Command Position registers (R0CH, R0DH, and R0EH) and the Actual Position registers (R12H, R13H, and R14H) to zero. After the Align mode has been executed, the HCTL-1000 will automatically enter the Position Control mode and go to position zero. By following this procedure, the largest movement in the Align mode will be 1 torque cycle of the motor.

The Align mode assumes: the encoder index pulse has been physically aligned to the last motor phase during encoder/motor assembly, the Commutator parameters have been correctly preprogrammed (see the section called *The Commutator* for details), and a hard reset has been executed while the motor is stationary.

The Align mode first disables the Commutator and with open loop control enables the first phase (PHA) and then the last phase (PHC or PHD) to orient the motor on the last phase torque detent. Each phase is energized for 2048 system sampling periods (t). For proper operation, the motor must come to a complete stop during the last phase enable. At this point the Commutator is enabled and commutation is closed loop.

The HCTL-1000 then switches automatically from the Align mode to Position Control mode.

Control Modes

Control flags F0, F3, and F5 in the Flag register (R00H) determine which control mode is executed. *Only one control flag can be set at a time.* After one of these control flags is set, the control modes are entered either automatically from Align or from the Initialization/Idle mode by writing 03H to the Program Counter (R05H).

1. POSITION CONTROL

F0, F3, F5 cleared.

Position Control performs point-to-point position moves with no velocity profiling. The user specifies a 24-bit position command, which the controller compares to the 24-bit actual position. The position error is calcuated, the full digital lead compensation is applied and the motor command is output.

The controller will remain position-locked at a destination until a new position command is given.

The actual and command position data is 24-bit two's-complement data stored in six 8-bit registers. Position is measured in encoder quadrature counts.

The command position resides in R0CH (MSB), R0DH, R0EH (LSB). Writing to R0EH latches all 24 bits at once for the control algorithm. Therefore, the command position is written in the sequence R0CH, R0DH and R0EH. The command registers can be read in any desired order.

The actual position resides in R12H (MSB), R13H, and R14H (LSB). Reading R14H latches the upper two bytes into an internal buffer. Therefore, Actual Position registers are read in the order of R14H, R13H, and R12H for correct instantaneous position data. The Actual Position registers cannot be written to, but they can all be cleared to 0 simultaneously by a write to register R13H.

The largest position move possible in Position Control mode is 7FFFFFH (8,388,607D) quadrature encoder counts.

2. PROPORTIONAL VELOCITY CONTROL

F3 set

Proportional Velocity Control performs control of motor speed using only the gain factor, K, for compensation. The dynamic pole and zero lead compensation are not used. (See the "Digital Filter" section of this data sheet.)

The command and actual velocity are 16-bit two's-complement words.

The command velocity resides in registers R24H (MSB) and R23H (LSB). These registers are unlatched which means that the command velocity will change to a new velocity as soon as the value in either R23H or R24H is changed. The registers can be read or written to in any order.

R24H	R23H
IIII IIII	IIII.FFFF

COMMAND VELOCITY FORMAT

The units of velocity are quadrature counts/sample time. To convert from rpm to quadrature counts/sample time, use the formula shown below:

$$Vq = (Vr)(N)(t)(0.01667/rpm\text{-}sec) \quad [5]$$

Where:

Vq =velocity in quadrature counts/sample time
Vr = velocity in rpm
N = 4 times the number of slots in the codewheel (i.e., quadrature counts).
t = The HCTL-1000 sample time in seconds. (See the section on the HCTL-1000's Sample Timer register).

Because the Command Velocity registers (R24H and R23H) are internally interpreted by the HCTL-1000 as 12 bits of integer and 4 bits of fraction, the host processor must multiply the desired command velocity (in quadrature counts/sample time) by 16 before programming it into the HCTL-1000's Command Velocity registers.

The actual velocity is computed only in this algorithm and stored in scratch registers R35H (MSB) and R34H (LSB). There is no fractional component in the actual velocity registers and they can be read in any order.

The controller tracks the command velocity continuously until new mode command is given. The system behavior after a new velocity command is governed only by the system dynamics until a steady state velocity is reached.

3. INTEGRAL VELOCITY CONTROL

F5 set

Integral Velocity Control performs continuous velocity profiling which is specified by a command velocity and command acceleration. Figure 5 shows the capability of this control algorithm.

The user can change velocity and acceleration any time to continuously profile velocity in time. Once the specified velocity is reached, the HCTL-1000 will maintain that velocity until a new command is specified. Changes between actual velocities occur at the presently specified linear acceleration.

The command velocity is an 8-bit two's-complement word stored in R3CH. The units of velocity are quadrature counts/sample time.

The conversion from rpm to quadrature counts/sample time is shown in equation 5. The Command Velocity register (R3CH) contains only integer data and has no fractional component.

While the overall range of the velocity command is 8 bits, two's-complement, the difference between any two sequential commands cannot be greater than 7 bits in magnitude (i.e., 127 decimal). For example, when the HCTL-1000 is executing a command velocity of 40H (+64D), the next velocity command must fall in the range of 7FH (+127D), the maximum command range, to C1H (–63D), the largest allowed difference.

The command acceleration is a 16-bit scalar word stored in R27H and R26H. The upper byte (R27H) is the integer part and the lower byte (R26H) is the fractional part

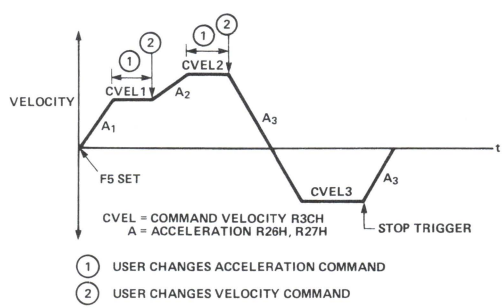


Figure 5. Integral Velocity Mode

provided for resolution. The integer part has a range of 00H to 7FH. The contents of R26H are internally divided by 256 to produce the fractional resolution.

R27H	R26H
0IIIIIII	FFFFFFFF/256

COMMAND ACCELERATION FORMAT

The units of acceleration are quadrature counts/sample time squared.

To convert from rpm/sec to quadrature counts/[sample time]^2, use the formula shown below:

$Aq = (Ar)(N)(t^2)(0.01667/rpm\text{-}sec)$ [6]

Where:

Aq = Acceleration in quadrature counts/[sample time]^2
Ar = Acceleration in rpm/sec
N = 4 times the number of slots in the codewheel (i.e., quadrature counts)
t = The HCTL-1000 sample time in seconds. (See the section on the HCTL-1000's Sample Timer register).

Because the Command Acceleration registers (R27H and R26H) are internally interpreted by the HCTL-1000 as 8 bits of integer and 8 bits of fraction, the host processor must multiply the desired command acceleration (in quadrature counts/[sample time]^2) by 256 before programming it into the HCTL-1000's Command Acceleration registers.

Internally, the controller performs velocity profiling through position control.

Each sample time, the internal profile generator uses the information which the user has programmed into the Command Velocity register (R3CH) and the Command Acceleration registers (R27H and R26H) to determine the value which will be automatically loaded into the Command Position registers (R0CH, R0DH, and R0EH). After the new command position has been generated, the difference between the value in the Actual Position registers (R12H, R13H, and R14H) and the new value in the Command Position registers is calculated as the new position error. This new position error is used by the full digital compensation filter to compute a new motor command output for this sample time. The register block diagram in Figure 3 further shows how the internal profile generator works in Integral Velocity mode. In control theory terms, integral compensation has been added and therefore, this system has zero steady-state error.

Although Integral Velocity Control mode has the advantage over Proportional Velocity mode of zero steady state velocity error, its disadvantage is that the closed loop stability is more difficult to achieve. In Integral Velocity Control mode, the system is actually a position control system and therefore the complete dynamic compensation D(z) is used.

If the external Stop flag F6 is set during this mode signaling an emergency situation, the controller automatically decelerates to zero velocity at the presently specified acceleration factor and stays in this condition until the flag is cleared. The user then can specify new velocity profiling data.

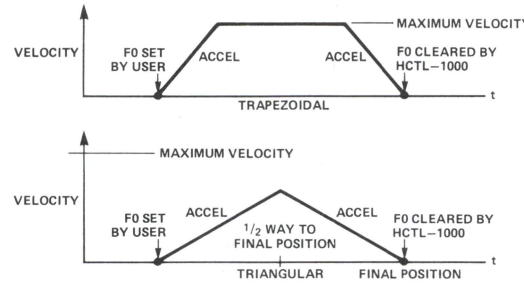


Figure 6. Trapezoidal Profile Mode

4. TRAPEZOIDAL PROFILE CONTROL

F0-Set

Trapezoidal Profile Control performs point-to-point position moves and profiles the velocity trajectory to a trapezoid or triangle. The user specifies only the desired final position, acceleration and maximum velocity. The controller computes the necessary profile to conform to the command data. If maximum velocity is reached before the distance halfway point, the profile will be trapezoidal, otherwise the profile will be triangular. Figure 6 shows the possible trajectories with Trapezoidal Profile control.

The command data for Trapezoidal Profile Control mode consists of a final position, a command acceleration, and a maximum velocity. The 24-bit, two's-complement final position is written to registers R2BH, (MSB), R2AH, and R29H (LSB). The 16-bit command acceleration resides in registers R27H (MSB) and R26H (LSB). The command acceleration has the same integer and fraction format as discussed in the Integral Velocity Control mode section. The 7-bit maximum velocity is a scalar value with the range of 00H to 7FH (0D to 127D). The maximum velocity has the units of quadrature counts per sample time, and resides in register R28H. The command data registers may be read or written to in any order.

The internal profile generator produces a position profile using the present Command Position (R0CH-R0EH) as the starting point and the Final Position (R2BH-R29H) as the end point.

Once the desired data is entered, the user sets flag F0 in the Flag register (R00H) to commence motion (if the HCTL-1000 is already in Position Control mode).

When the profile generator sends the last position command to the Command Position registers to complete the trapezoidal move, the controller clears flag F0. The HCTL-1000 then automatically goes to Position Control mode with the final position of the trapezoidal move as the command position.

When the HCTL-1000 clears flag F0 it does NOT indicate that the motor and encoder are at the final position NOR that the motor and encoder have stopped. The motor and encoder's true position can only be determined by reading the Actual Position registers. The only way to determine if the motor and encoder have stopped is to read the Actual Position registers at successive intervals.

The status of the Profile flag can be monitored both in the Status register (R07) and at the external Profile pin (pin 12) at any time. While the Profile flag is high NO new command data should be sent to the controller.

Each sample time, the internal profile generator uses the information which the user has programmed into the Maximum Velocity register (R28H), the Command Acceleration registers (R27H and R26H), and the Final Position registers (R2BH, R2AH, and R29H) to determine the value which will be automatically loaded into the Command Position registers (R0EH, R0DH, and R0CH). After the new command position has been generated, the difference between the value in the Actual Position registers (R12H, R13H, and R14H) and the new value in the Command Position registers is calculated as the new position error. This new position error is used by the full digital compensation filter to compute a new motor command ouput for the sample time. (The register block diagram in Figure 3 further shows how the internal profile generator works in Trapezoidal Profile mode.)

COMMUTATOR

The commutator is a digital state machine that is configured by the user to properly select the phase sequence for electronic commutation of multiphase motors. The Commutator is designed to work with 2, 3, and 4-phase motors of various winding configurations and with various encoder counts. Along with providing the correct phase enable sequence, the Commutator provides programmable phase overlap, phase advance, and phase offset.

Phase overlap is used for better torque ripple control. It can also be used to generate unique state sequences which can be further decoded externally to drive more complex amplifiers and motors.

Phase advance allows the user to compensate for the frequency characteristics of the motor/amplifier combination. By advancing the phase enable command (in position), the delay in reaction of the motor/amplifier combination can be offset and higher performance can be achieved.

Phase offset is used to adjust the alignment of the commutator output with the motor torque curves. By correctly aligning the HCTL-1000's commutator output with the motor's torque curves, maximum motor output torque can be achieved.

The inputs to the Commutator are the three encoder signals, Channel A, Channel B, and Index, and the configuration data stored in registers.

The Commutator uses both channels and the index pulse of an incremental encoder. The index pulse of the encoder must be physically aligned to a known torque curve location because it is used as the reference point of the rotor position with respect to the Commutator phase enables.

The index pulse should be permanently aligned during motor encoder assembly to the last motor phase. This is done by energizing the last phase of the motor during assembly and permanently attaching the encoder codewheel to the motor shaft such that the index pulse is active as shown in Figures 7 and 8. Fine tuning of alignment for commutation purposes is done electronically by the Offset register (R1CH) once the complete control system is set up.

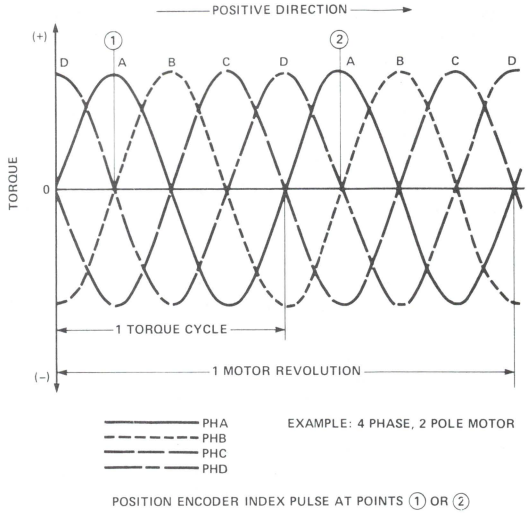


Figure 7. Index Pulse Alignment to Motor Torque Curves

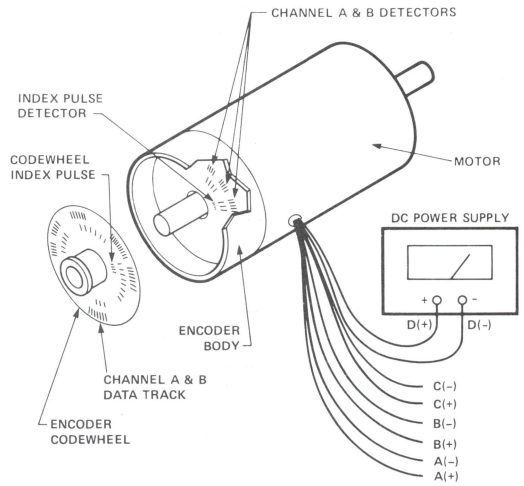


Figure 8. Codewheel Index Pulse Alignment

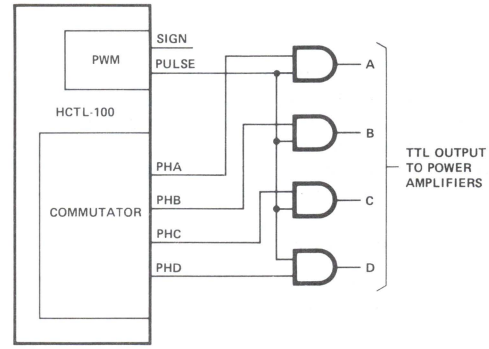


Figure 9. PWM Interface to Brushless DC Motors

Each time an index pulse occurs, the internal commutator ring counter is reset to 0. The ring counter keeps track of the current position of the rotor based on the encoder feedback. When the ring counter is reset to 0, the Commutator is reset to its origin (last phase going low, phase A going high) as shown in Figure 10.

The output of the Commutator is available as PHA, PHB, PHC, and PHD on pins 26-29. The HCTL-1000's commutator acts as the electrical equivalent of the mechanical brushes in a motor. Therefore, the outputs of the commutator provide only proper phase sequencing for bidirectional operation. The magnitude information is provided to the motor via the Motor Command and PWM ports. The outputs of the commutator must be combined with the outputs of one of the motor ports to provide proper DC brushless and stepper motor control. Figure 9 shows an example of circuitry which uses the outputs of the commutator with the Pulse output of the PWM port to control a DC brushless or stepper motor. A similar procedure could be used to combine the commutator outputs PHA-PHD with a linear amplifier interface output (Figure 15) to create a linear amplifier system.

Commutation Configuration Registers

The Commutator is programmed by the data in the following registers. Figure 10 shows an example of the relationship between all the parameters.

1. STATUS REGISTER (R07H)

Bit #1 -0 = 3-phase configuration, PHA, PHB, and PHC are active outputs.
1 = 4-phase configuration, PHA - PHD are active outputs.

Bit #2 - 0 = Rotor position measured in quadrature counts (4x decoding).
1 = Rotor position measured in full counts (1 count = 1 codewheel bar and space.)

Bit #2 only affects the commutator's counting method. This includes the Ring register (R18H), the X and Y registers (R1AH & R1BH), the Offset register (R1CH), the Velocity Timer register (R19H), and the Maximum Advance register (R1FH).

Quadrature counts (4x decoding) are always used by the HCTL-1000 as a basis for position, velocity, and acceleration control.

2. RING REGISTER (R18H)

The Ring register is defined as 1 electrical cycle of the commutator which corresponds to 1 torque cycle of the motor. The Ring register is scalar and determines the length of the commutation cycle measured in full or quadrature counts as set by bit #2 in the Status register (R07H). The value of the ring must be limited to the range of 0 to 7FH.

3. X REGISTER (R1AH)

This register contains scalar data which sets the interval during which only one phase is active.

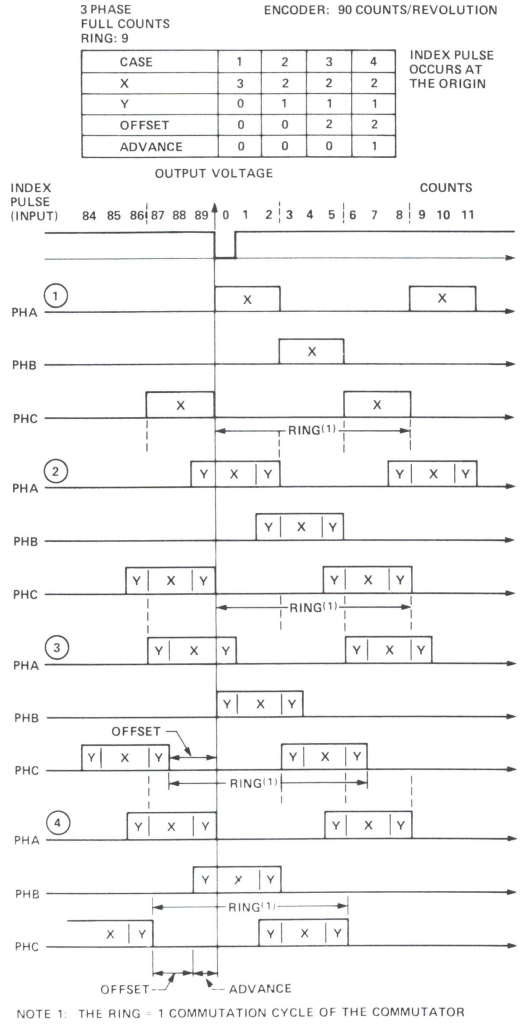


Figure 10. Commutator Configuration

4. Y REGISTER (R1BH)

This register contains scalar data which set the interval during which two sequential phases are both active. Y is phase overlap. X and Y must such that:

$$X + Y = \text{Ring}/(\#\text{ of phases}) \qquad [8]$$

These three parameters define the basic electrical commutation cycle.

5. OFFSET REGISTER (R1CH)

The Offset register contains two's-complement data which determines the relative start of the commutation cycle with respect to the index pulse. Since the index pulse must be physically referenced to the rotor, offset performs fine alignment between the electrical and mechanical torque cycles.

Advance = $N_f v \Delta t$ [9]

where $\Delta t = \frac{16\ (R19H + 1)}{f\ external\ clk}$ [10]

N_f = full encoder counts/revolution.
v = velocity (revolutions/second)

The Maximum Advance register (R1FH) contains scalar data which sets the upper limit for phase advance regardless of rotor speed.

Figure 11 shows the relationship between the Phase Advance registers. Note: If the phase advance feature is not used, set both R19H and R1FH to 0.

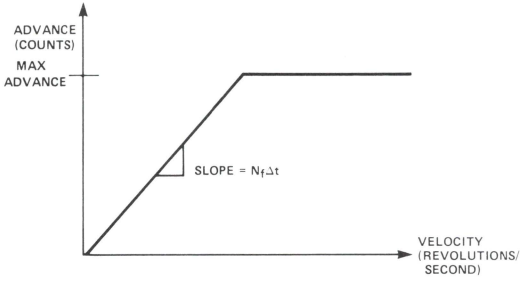


Figure 11. Phase Advance vs. Motor Velocity

Commutator Constraints and Use

When choosing a three-channel encoder to use with a DC brushless or stepper motor, the user should keep in mind that the number of quadrature encoder counts (4x the number of slots in the encoder's codewheel) must be an integer multiple (1x, 2x, 3x, 4x, 5x, etc.) of the number of pole pairs in the DC brushless motor or steps in a stepper motor. To take full advantage of the commutator's overlap feature, the number of quadrature counts should be at least 3 times the number of pole pairs in the DC brushless motor or steps in the stepper motor. For example, a 1.8°, 200 step/revolution stepper motor should employ at least 3 x 200 steps/rev = 600 quadrature counts/revolution = 150 cycles/rev codewheel.

Numerical constraints the user should be aware of to use the Commutator.

The parameters of Ring, X, Y, and Max Advance must be positive numbers (00H to 7FH). Additionally, the following equation must be satisfied:

$$(-86D)\ 80H \leq \frac{3}{2}\text{Ring} + \text{Offset} \pm \text{Max Advance} \leq 7FH\ (127D) \quad [11]$$

In order to utilize the greatest flexibility of the Commutator, it must be realized that the Commutator works on a circular ring counter principle, whose range is defined by the Ring register (R18H). This means that for a ring of 96 counts and a needed offset of 10 counts, numerically the Offset register can be programmed as 0AH (10D) or AAH (-86D), the latter satisfying Equation 11.

If bit #2 in the Status register is set to allow the commutator to count in full counts, a higher resolution codewheel may be chosen for precise motor control without violating the commutator constraints equation (Equation 11).

Example: Suppose you want to commutate a 3-phase 15 deg/step Variable Reluctance Motor attached to a 192 count encoder.

1. Select 3-phase and quadrature mode for commutator by writing 0 to R07H.
2. With a 3-phase 15 degree/step Variable Reluctance Motor the torque cycle repeats every 45 degrees or 8 times/revolution.
3. Ring register = $\frac{(4)(192)\ \text{counts/revolution}}{8/\text{revolution}}$

   = 96 quadrature counts
   = 1 commutation cycle
4. By measuring the motor torque curve in both directions, it is determined that an offset of 3 mechanical degrees, and a phase overlap of 2 mechanical degrees is needed.

$$\text{Offset} = 3° \frac{(4)(192)}{360°} \simeq 6 \text{ quadrature counts}$$

To create the 3 mechanical degree offset, the Offset register (R1CH) could be programmed with either A6H (-90D) or 06H (+06D). However, because 06H (+06D) would violate the commutator constraints Equation 11, A6H (-90D) is used.

$$Y = \text{overlap} = \frac{(2°)\ (4)\ (192)}{360°} \simeq 4$$

$$X + Y = 96/3$$

Therefore, X = 28
Y = 4

For the purposes of this example, the Velocity Timer and Maximum Advance are set to 0.

Interfacing the HCTL-1000

I/O INTERFACE

The HCTL-1000 looks to the host microprocessor like a bank of 8-bit registers to which the host processor can read and write. (i.e. The host processor treats the HCTL-1000 like RAM.) The data in these registers controls the operation of the HCTL-1000. The host processor communicates to the HCTL-1000 over a bi-directional multiplexed 8-bit data bus. The four I/O control lines (i.e. $\overline{CS}$, $\overline{OE}$, and R/$\overline{W}$ execute the data transfer.

There are three different timing configurations which can be used to give the user greater flexibility to interface the HCTL-1000 to most microprocessors (see Timing diagrams). They are differentiated from one another by the arrangement of the $\overline{ALE}$ signal with respect to the $\overline{CS}$ signal. The three timing configurations are listed below.

1. $\overline{ALE}$, $\overline{CS}$ non-overlapped
2. $\overline{ALE}$, $\overline{CS}$ overlapped
3. $\overline{ALE}$ within $\overline{CS}$

Any I/O operation starts by asserting the $\overline{ALE}$ signal which starts sampling the external bus into an internal address latch. Rising $\overline{ALE}$ or falling $\overline{CS}$ during $\overline{ALE}$ stops the sampling into the address latch.

$\overline{CS}$ low after rising $\overline{ALE}$ samples the external bus into the data latch. Rising $\overline{CS}$ stops the sampling into the data latch, and starts the internal synchronous process.

In the case of a write, the data in the data latch is written into the addressed location. In the case of a read, the addressed location is written into an internal output latch. $\overline{OE}$ low enables the internal output latch onto the external bus. The $\overline{OE}$ signal and the internal output latch allow the I/O port to be flexible and avoid bus conflicts during read operations.

It is important that the host microprocessor does not attempt to perform too many I/O operations in a single sample time of the HCTL-1000. Each I/O operation interrupts the execution of the HCTL-1000's internal code for 1 clock cycle. Although extra clock cycles have been allotted in each sample time for I/O operations, the number of extra cycles is reduced as the value programmed into the Sample Timer register (R0FH) is reduced.

Table II shows the maximum number of I/O operations allowed under the given conditions.

TABLE II: MAXIMUM NUMBER OF I/O ALLOWED

Sample Timer Register Value	Operating Mode	Maximum Number of I/O Operations Allowed/Sample
07H (07D)	Positon Control or Prop. Vel. Control	5
0FH (15D)	Positon Control or Prop. Vel. Control	133
	Trapezoidal Prof. or Integral Vel. Control	6

The number of external clock cycles available for I/O operations in any of the above modes can be increased by increasing the value in the Sample Timer register (R0FH). For example, the HCTL-1000 accepts inputs from 5000, 6000 and 6010 series encoders. Channels A and B are internally decoded into quadrature counts which increment the 24-bit position counter. For example, a 500 count per revolution encoder will be incremented when 2000 quadrature counts pelevant. The Index channel is used to ... Its function is to serve as a ... Ring Counter.

The HCTL-1000 employs an input counter to remove any noise spikes from ... HCTL-1000. This 3-bit state delay allows inputs to remain stable for three ... edges for an encoder pulse to be ... HCTL-1000's actual position counter. ... must remain at a logic level high or low ... tive clock rising edges for the HCTL-1000's ... counter to be incremented or decremented.) The designer should therefore generally avoid creating encoder pulses of less than 3 clock cycles.

In a real system that has been designed so that the maximum velocity of the encoder will not create encoder pulses less than 3 clock cycles in duration, it is possible to create an encoder pulse of less than 3 clock cycles if the direction of the motor's rotation is reversed coincidentally with an encoder pulse state transition. If this encoder pulse is between 2 and 3 clock cycles in length and its trailing edge transition occurs within 2 nanoseconds of the falling edge of the clock, a single erroneous count will register in the HCTL-1000's Actual Position counter. (See Figure 13).

Notice that the probability of all three conditions occurring which could cause an erroneous encoder count (a direction reversal on an encoder edge, a created encoder pulse of 2 to 3 clock cycles in duration, and the trailing edge transition of the encoder pulse occurring within 2 nanoseconds of the falling edge of the clock) is low in a real system.

The recommended encoder interface circuitry shown in Figure 14 prevents any possibility of an erroneous encoder count occurring due to the conditions explained above. This circuitry ensures that all encoder pulse transitions occur at the HCTL-1000 encoder inputs coincident with the rising edge of the D flip-flop's clock. Therefore, even if a pulse of 2 to 3 clock cycles is created by the encoder, it is prevented from having an edge that occurs within 2 nanoseconds of the falling edge of the clock and thus an erroneous encoder pulse will not be counted by the HCTL-1000.

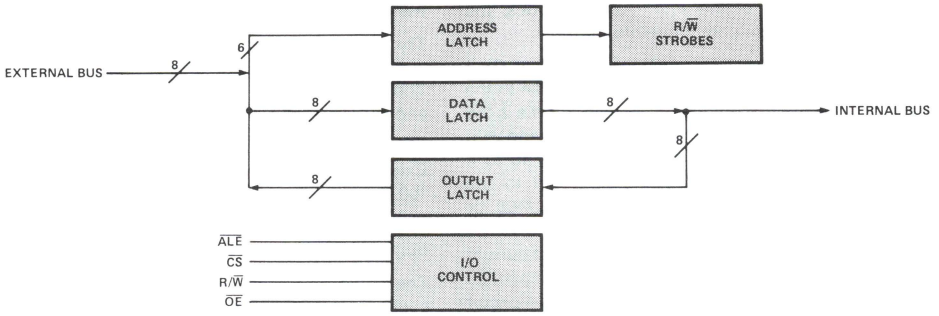


Figure 12. I/O Port Block Diagram

The D flip-flops used in the recommended interface circuitry gate all transitions of the encoder signals at the D inputs with the rising edge of the clock input. The clock used to drive the D flip-flops is the same 1 to 2 MHz clock used to drive the HCTL-1000. The Q outputs of the D flip-flops cause the A and B inputs of the HCTL-1000 to change state according to the state of each D input on the rising edge of the clock signal.

If the recommended encoder interface circuitry is not used, the position drift caused by any erroneous encoder counts can be controlled by occasionally returning the motion control system to some known "home" position where the actual position registers can be reset to zero.

The possibility of any erroneous encoder counts occurring can be completely eliminated by employing the recommended encoder interface circuitry shown in Figure 14.

The index signal of an encoder is used in conjunction with the Commutator. It resets the internal ring counter which keeps track of the rotor position so that no cumulative errors are generated.

The Index pin of the HCTL-1000 also has a 3-bit filter on its input. The Index pin is *active low and level transition sensitive.* It detects a valid high-to-low transition and qualifies the low input level through the 3-bit filter. At this point, the Index signal is internally detected by the commutator logic. This type of configuration allows an Index or $\overline{\text{Index}}$ signal to be used to generate the reference mark for commutator operation as long as the AC specifications for the Index signal are met.

AMPLIFIER INTERFACE

The HCTL-1000 outputs a motor command in two forms: an 8-bit Motor Command which can be connected to a DAC to drive a linear amplifier and Pulse and Sign output to drive a PWM amplifier.

All control algorithms internally compute an error between the desired command and actual feedback which is processed through the digital filter. The result is an internal 8-bit 2's-complement motor command. Before the internal motor command is made externally available, it is additionally adjusted for different output formats and ease of interfacing to external hardware. The sections below discuss the externally available amplifier interfaces and their formats. Tables II and III summarize the amplifier interface outputs.

8-Bit Parallel Motor Command Port

The 8-bit Motor Command port consists of register R08H whose data goes directly to external pins MC0-MC7. MC7 is the most significant bit. R08H can be read and written to, however, it should be written to only during Initialization/

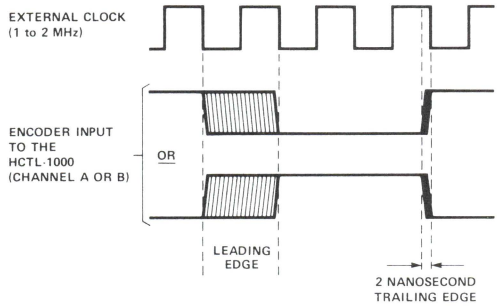


Figure 13. Encoder Input Conditions Which Will Cause an Erroneous Count in the HCTL-1000's Actual Position Counter

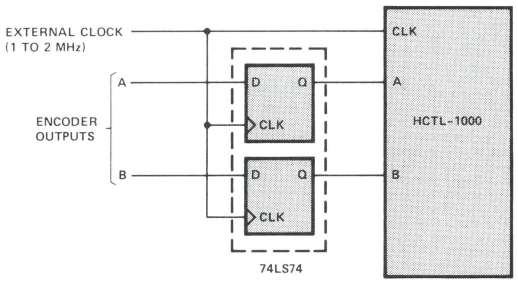


Figure 14. Recommended D Flip-Flop Encoder Interface Circuit for the HCTL-1000

Idle mode. During any of the four Control modes, the controller writes the motor command into R08H.

The Motor Command port is the ideal interface to an 8-bit DAC, configured for bipolar output. The data written to the 8-bit Motor Command port by the control algorithms is the internally computed 2's-complement motor command with an 80H offset added. This allows direct interfacing to a DAC. Figure 15 shows a typical DAC interface to the HCTL-1000. An inexpensive DAC, such as MC1408 or equivalent, has its digital inputs directly connected to the Motor Command port. The DAC produces an output current which is converted to a voltage by an operational amplifier. R_O and R_G control the analog offset and gain. The circuit is easily adjusted for +5 V to -5 V operation by first writing 80H to R08H and adjusting R_O for 0 V output. Then FFH is written to R08H and R_G is adjusted until the output is 5 V. Note that 00H in R08H corresponds to -5 V out.

The above interface is suitable to drive linear amplifiers and DC motors because of the bipolar output. When using commutated motors, the direction of rotation of the motor is governed by the order of firing the motor phases which is under commutator control. In this case, it is desirable to have the Motor Command be unipolar to specify magnitude only, not direction. The HCTL-1000 has the feature of digitally configuring the 8-bit Motor Command port into unipolar mode. Flag F2 in the Flag register R00H controls this function.

F2 clear — Bipolar mode
F2 set — Unipolar mode

This mode functions such that, with the same circuit in Figure 15 (or any DAC configured for similar bipolar operation) setting F2 will cause the DAC to output from 0 V to 5 V only and the digital data on pins MC0 to MC7 to be restricted in the control modes from 80H to FFH. Internally the commutator keeps track of the sign of the motor command for proper commutation of the motor.

Internally, the HCTL-1000 operates on data of 24, 16 and 8-bit lengths to produce the 8-bit motor command, available externally. Many times the computed motor command will be greater than 8 bits. At this point, the motor command is saturated by the controller. The saturated value output by the controller is not the full scale value 00H (00D), or FFH (255D). The saturated value is adjusted to 0FH (15D) (negative saturation) and F0H (240D) (positive saturation). Saturation levels for the Motor Command port are also included in Figure 16.

PWM Port

The PWM port outputs the motor command as a pulse width modulated signal with the correct sign of polarity. The PWM port consists of the Pulse and Sign pins (pins 16 and 17) and R09H.

The PWM signal at the Pulse pin has a frequency of External Clock/100 and the duty cycle is resolved into the 100 clocks.

The Sign pin gives the polarity of the command. Low output on Sign pin is positive polarity.

The 2's-complement contents of R09H determine the duty cycle and polarity of the PWM command. For example, D8H (-40D) gives a 40% duty cycle signal at the Pulse pin and forces the Sign pin high. Data outside the 64H (+100D) to 9CH (-100D) linear range gives 100% duty cycle. R09H can be read and written to. However, the user should only write to R09H when the controller is in the Initialization/Idle mode. Figure 17 shows the PWM output versus the internal motor command.

When any Control mode is being executed, the unadjusted internal 2's-complement motor command is written to R09H. Because of the hardware limit on the linear range (64H to 9CH, ±100D), the PWM port saturates sooner than the 8-bit Motor Command port (00H to FFH, +127D to -128D). When the internal motor command saturates above 8 bits, the PWM port is saturated to the full ±100% duty cycle level. Figure 17 shows the actual values inside the PWM port. Note that the Unipolar flag, F2, does *not* affect the PWM port.

For commutation of brushless motors with the PWM port, only use the Pulse pin (pin 16) from the PWM port as the commutator already contains sign information. (See Figure 9).

The PWM port has an option that can be used with H-bridge type amplifiers. The option is Sign Reversal Inhibit, which inhibits the Pulse output for one PWM period after a sign polarity reversal. This allows one pair of transistors to turn off before others are turned on and thereby avoids a short across the power supply. Bit 0 in the Status register (R07H) controls the Sign Reversal Inhibit option. Figure 18 shows the output of the PWM port when Bit 0 is set.

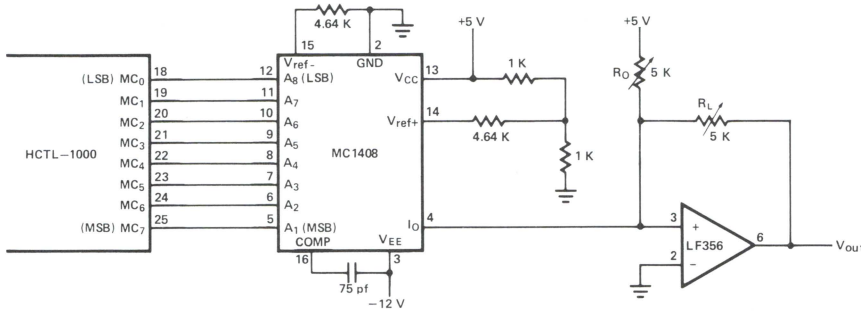


Figure 15. Linear Amplifier Interface

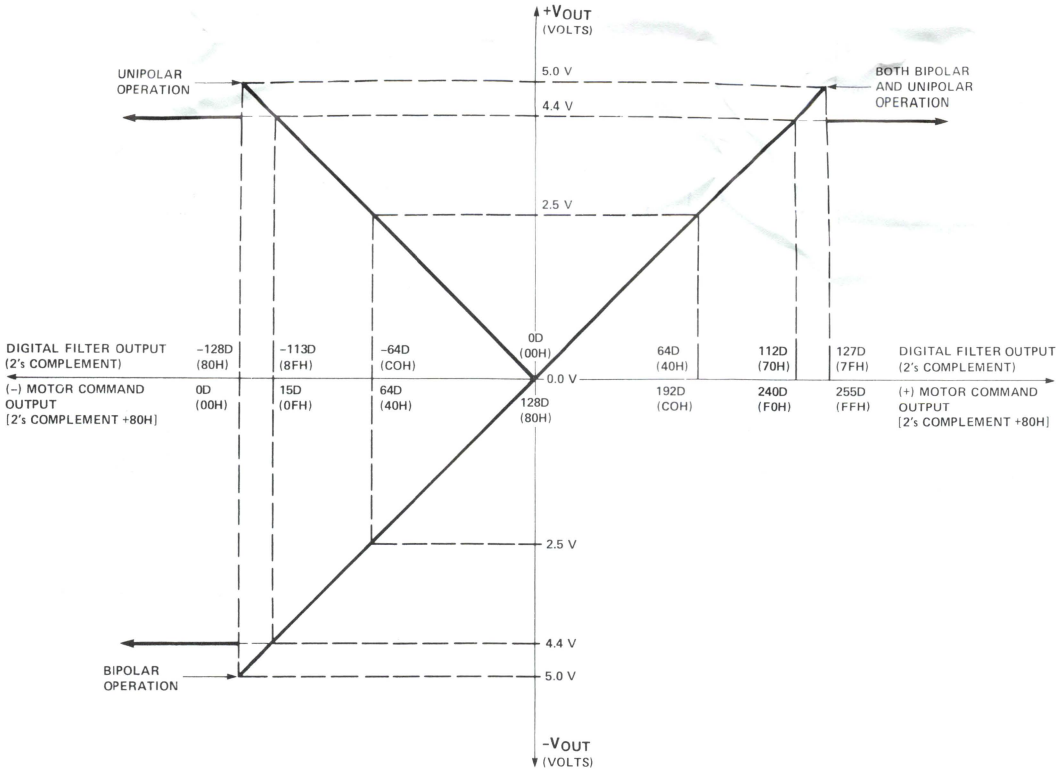


Figure 16. Motor Command Port Output

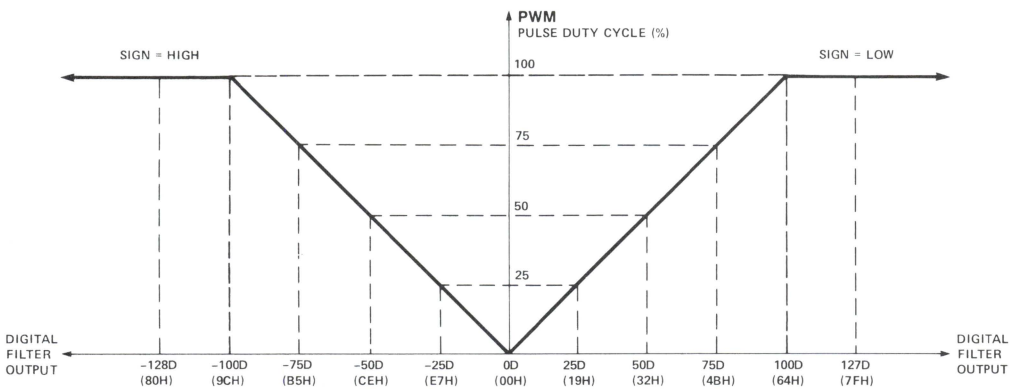


Figure 17. PWM Port Output

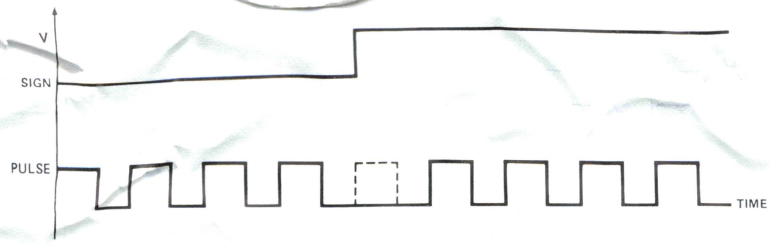


Figure 18. Sign Reversal Inhibit

Figure 19 shows an example of how to interface the HCTL-1000 to an H-bridge amplifer. An H-bridge amplifier allows bipolar motor operation with a unipolar power supply. The Sign Reversal Inhibit feature prevents all transistors from being on at the same time when the direction of motion is reversed.

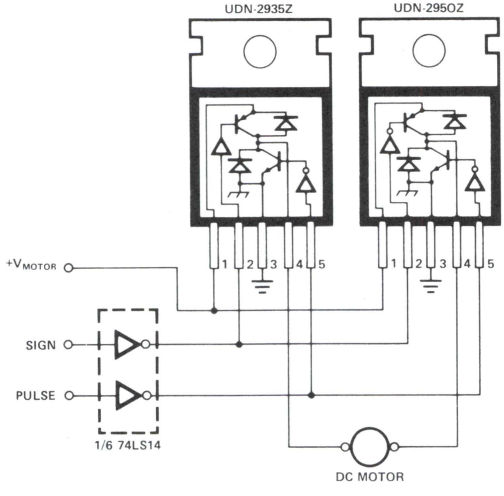


Figure 19. H-Bridge Amplifier Interface

HEWLETT PACKARD

QUADRATURE DECODER/ COUNTER INTERFACE IC

HCTL-2000

TECHNICAL DATA JANUARY 1986

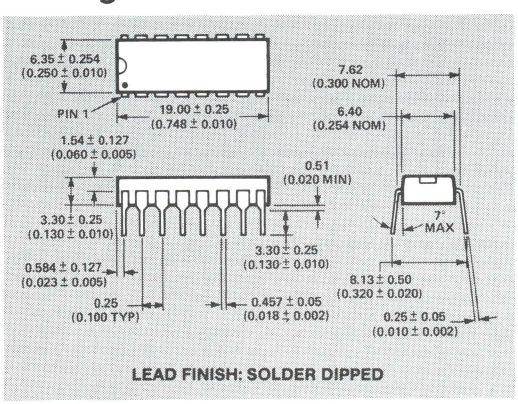
Features

- **FULL FUNCTION IN A SPACE SAVING PACKAGE**
- **SUBSTANTIALLY REDUCED SYSTEM SOFTWARE**
- **FULL 4X DECODE**
- **HIGH NOISE IMMUNITY:**
  SCHMITT TRIGGER INPUTS
  DIGITAL NOISE FILTER
- **8 BIT TRISTATE INTERFACE**
- **12 BIT BINARY UP/DOWN COUNTER TO BUFFER THE CONTROL PROCESSOR**
- **12 BIT LATCH AND INHIBIT LOGIC PROVIDE A STABLE, 2 BYTE READ OPERATION**
- **8 AND 12 BIT OPERATING MODES**

Description

The HCTL-2000 is an HCMOS IC that performs the quadrature decoder, counter, and bus interface function. The HCTL-2000 is designed to improve system performance in digital closed loop motion control systems and digital data input systems. It does this by shifting time intensive quadrature decoder functions to a cost effective hardware solution. The HCTL-2000 consists of a 4x quadrature decoder, 12 bit binary up/down state counter, and 8 bit bus interface. The use of Schmitt triggered CMOS inputs and a 3 bit state delay filter allows reliable operation in noisy environments. The HCTL-2000 provides LSTTL compatible tri-state output buffers. Operation is specified for a temperature range from -40 to +85° C at clock frequencies up to 3.9 mHz.

Package Dimensions



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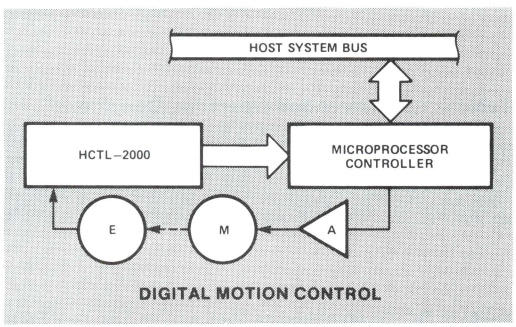
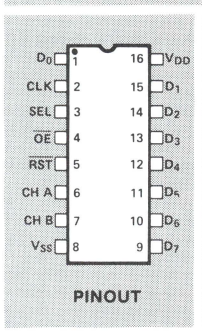
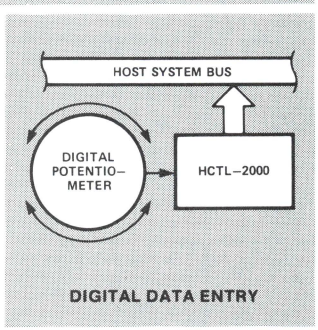


DIGITAL MOTION CONTROL



PINOUT



DIGITAL DATA ENTRY

Applications

- **INTERFACE QUADRATURE INCREMENTAL ENCODERS TO MICROPROCESSORS**
- **INTERFACE DIGITAL POTENTIOMETERS TO DIGITAL DATA INPUT BUSSES**

Table of Contents

- **OPERATING CHARACTERISTICS** 2
- **FUNCTIONAL PIN DESCRIPTIONS** 3
- **SWITCHING CHARACTERISTICS** 4
- **OPERATION** 6
- **FILTER OPTIMIZATION** 9
- **INTERFACING** 11
  - **— GENERAL** 11
  - **— TO MOTOROLA 6801** 12
  - **— TO INTEL 8748** 13

ESD WARNING: HCTL-2000 is implemented in a standard HCMOS process with diode protection of all I/O pads. Standard precautions for handling HCMOS devices should be observed.

MOTION SENSING AND CONTROL

Operating Characteristics

Table 1. Absolute Maximum Ratings (all voltages below are referenced to V_{SS})

Parameter	Symbol	Limits	Units
DC Supply Voltage	V_{dd}	−0.3 to +7	V
Input Voltage	V_{in}	−0.3 to V_{dd} +0.3	V
Storage Temperature	T_s	−40 to +125	°C
Operating Temperature	T_a[1]	−40 to +85	°C

Table 2. Recommended Operating Conditions

Parameter	Symbol	Limits	Units
DC Supply Voltage	V_{dd}	+3 to +6	V
Ambient Temperature	T_a[1]	−40 to +85	°C

Table 3. DC Characteristics $V_{dd} = 5V \pm 5\%$; $T_a = -40$ to $+85°C$

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{il}[2]	Low-Level Input Voltage				1.5	V
V_{ih}[2]	High-Level Input Voltage		3.5			V
V_{t+}[2]	Schmitt-Trigger Positive-Going Threshold			3.0	4.0	V
V_{t-}[2]	Schmitt-Trigger Negative-Going Threshold		1.0	1.5		V
V_h	Schmitt-Trigger Hysteresis		1.0	1.5		V
I_{in}	Input Current	$V_{in} = V_{dd}$ $V_{in} = V_{ss}$	−10 −10	1 1	+10 +10	μA μA
V_{oh}[2]	High-Level Output Voltage	$I_{oh} = -1.6mA$	2.4	4.5		V
V_{ol}[2]	Low-Level Output Voltage	$I_{ol} = +1.6mA$		0.2	0.4	V
I_{oz}	High-Z Output Leakage Current	$V_o = V_{ss}$ or V_{dd}	−10	1	+10	μA
I_{dd}	Quiescent Supply Current	$V_{in} = V_{ss}$ or V_{dd} V_d = HiZ		60		μA
C_{in}	Input Capacitance	Any Input[3]		5		pF
C_{out}	Output Capacitance	Any Output[3]		7		pF

NOTES:

1. Free Air.
2. In general, for any V_{dd} between the allowable limits (+3V to +6V), $V_{il} = 0.3V_{dd}$ and $V_{ih} = 0.7V_{dd}$; V_t+ and V_t- vary as Fig 1; $V_{oh} = V_{dd} - 0.5V$ and $V_{ol} = V_{ss} + 0.2V$ @ (±) 1.6 ma respectively.
3. Excluding package capacitance.

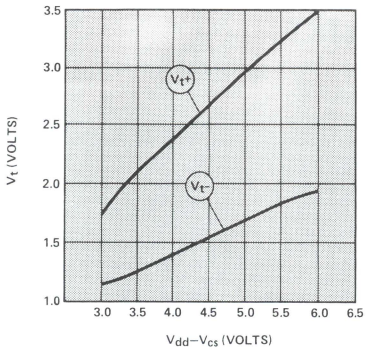


Figure 1. Typical Schmitt Trigger Input Threshholds

Functional Pin Descriptions

Table 4. Functional Pin Descriptions

Symbol	Pin	Description
V_{dd}	16	Power Supply
V_{ss}	8	Ground
CLK	2	The rising edge of this Schmitt trigger input controls the sampling of the CHA and CHB inputs, and the clocking of the input of the noise filters, decoder, counter and internal data latch. The falling edge of the CLK input controls the sampling of the OE and SEL inputs to control the inhibit logic.
CHA	6	CHA and CHB are Schmitt trigger inputs which accept the output from a quadrature encoded source, such as an incremental optical shaft encoder. The 4x decoding into states produces count and direction information where the number of states is 4 times the number of pulses on CHA or CHB (See Figure 8). Non-ideal state width affects the relationship between the clock frequency and the maximum encoder line frequency: See "Digital Filter" and "Quadrature Decoder" section.
CHB	7	
$\overline{RST}$	5	This active low Schmitt trigger input clears the internal 12 bit up/down position counter and the position latch. It also resets the inhibit logic. $\overline{RST}$ is asynchronous with respect to any other input signals. $\overline{RST}$ does not clear the input filter state machine nor the decoder state machine.
$\overline{OE}$	4	This HCMOS active low input directly controls the tri-state output buffers. In addition, the $\overline{OE}$ and SEL inputs are sampled by the internal inhibit logic on the falling edge of the clock to control the loading of the internal position data latch. The above operation constrains the timing of $\overline{OE}$ and SEL to be synchronous with the falling clock edge during two byte read operations. See "Inhibit Logic".
SEL	3	This HCMOS input directly controls which data byte from the position latch is enabled into the 8 bit tri-state output buffer. As in $\overline{OE}$ above, SEL also controls the internal inhibit logic. SEL = 0: high byte SEL = 1: low byte
D0	1	These LSTTL compatible tri-state outputs form an 8 bit output port through which the contents of the 12 bit position latch may be read in 2 sequential bytes. Inhibit logic disables the position data latch inputs at the start of the read operation to hold the data stable throughout the 2 byte read operation. Once commenced, this sequence must be completed, or $\overline{RST}$ must be used to reset the inhibit logic, with resulting data loss. The high byte, containing bits 8-11, is read first. The most significant 4 bits of this byte are set to 0 internally. The lower byte, bits 0-7, is read second.
D1	15	
D2	14	
D3	13	
D4	12	
D5	11	
D6	10	
D7	9	

Switching Characteristics

Table 5. Switching Characteristics Min/Max specifications at V_{dd} = 5.0 ± 5%, T_a = −40 to +85° C; Typicals are representative of V_{dd} = 5.0V, T_{case} = 25° C

		Symbol Description	Min.[1]	Typ.[2]	Max.[1]	Units
1	T_{clk}	Rising edge to rising edge of clock period	255	136	—	ns
2	T_{chh}	Minimum clock high hold time	125	70	—	ns
3	T_{cd} [3]	Delay from rising edge of clock to valid, updated count information on D0-7	—	126	230	ns
4	T_{ode} [5]	OE to valid data on D0-7	—	47	86	ns
5	T_{odz}	OE delay to Hi-Z state on D0-7	—	30	55	ns
6	T_{sdv} [4]	SEL valid to stable, selected data byte, delay to High Byte=delay to Low Byte	—	71	129	ns
7	T_{clh}	Minimum clock low hold time	35	20	—	ns
8	T_{ss} [6]	SEL setup time prior to falling clock edge	36	20	—	ns
9	T_{os} [6]	OE setup time prior to falling clock edge	31	17	—	ns
10	T_{sh} [6]	Hold time of SEL after falling clock edge	0	—	—	ns
11	T_{oh} [6]	Hold time of OE after falling clock edge	0	—	—	ns
12	T_{rst}	RST active low hold time	50	27	—	ns
13	T_{dcd}	Output Delay Time: Last Position Count Stable on D0-7 after Rising Clock Edge.	5	36	—	ns
14	T_{dsd}	Output Delay Time: Last Data Byte Stable after next SEL state change.	4	31	—	ns
15	T_{dod}	Output Delay Time: Data Byte Stable after $\overline{OE}$ Rising Edge	3	25	—	ns

NOTES:

1. All times specified from valid logic level to valid logic level of relevant I/O pins. Conformance to these limits is necesary to insure proper operation over T_a = −40 to +85° C.
2. Typical times are for reference only.
3. T_{cd} specification and waveform assume valid stable SEL and $\overline{OE}$ from T = $-\infty$
4. T_{sdv} specification and waveform assume data stable and valid on internal multiplexer inputs prior to the SEL transition.
5. T_{ode} specification and waveform assume data stable on buffer inputs.
6. T_{ss}, T_{os}, T_{sh}, T_{oh} only pertain to proper operation of the inhibit logic. In other cases, such as 8 bit read operations, these setup and hold times do not need to be observed.

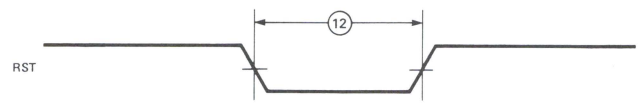


Figure 2. Reset Waveform

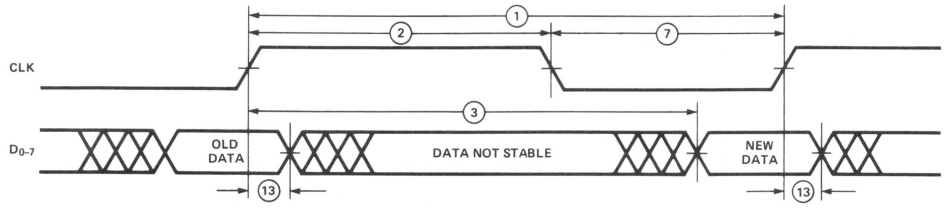


Figure 3. Waveforms for Positive Clock Edge Related Delays

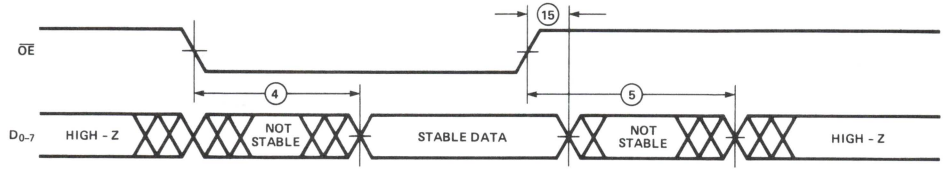


Figure 4. Tri-State Output Timing

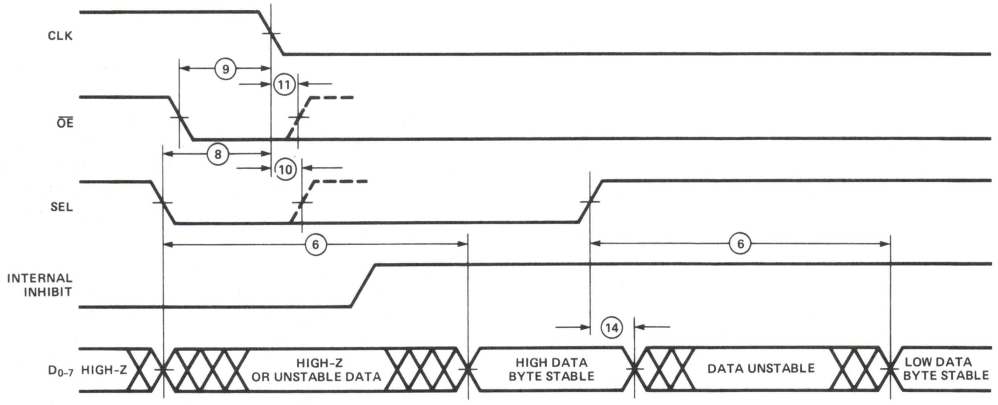


Figure 5. Bus Control Timing

Operation

A detailed block diagram of the HCTL-2000 is shown in Figure 6. The operation of each major function is described in the following sections.

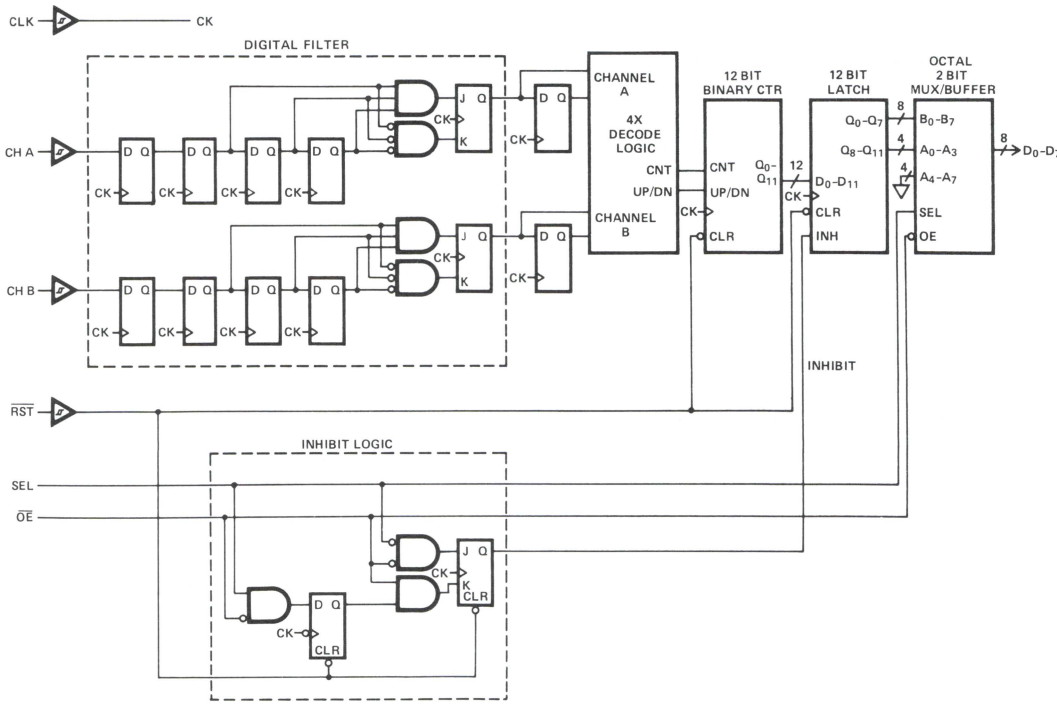


Figure 6. Simplified Logic Diagram

DIGITAL FILTER

The digital filter section is responsible for rejecting noise on incoming quadrature signals. Schmitt-trigger conditioning addresses the problems of slow rise and fall times and low level noise. The major task of the filter is to deal with short-duration noise pulses that cause the input logic level to momentarily change. Due to the nature of quadrature decoding, noise pulses on one channel will not cause a count error, but the coincidence of two overlapping noise pulses, one on each input, can cause illegal state transitions. False counts of undetermined direction will result from the decoding of these illegal transitions (see Fig. 8).

A pair of filters rejects these noise pulses by sampling the CHA and CHB logic levels and storing a time history in a pair of shift registers. For each channel, if the input level has had the same value on three consecutive rising clock edges, that value becomes the new output of the filter; otherwise the output is unchanged. This means that the CHA filter output cannot change from high to low until the CHA input has been low for three consecutive rising clock edges. CHB is treated the same as CHA.

The operation of this digital filter section places one of two timing constraints on the minimum clock frequency in relationship to the encoder count frequency. The first constraint derives from the operation of the input filters. It relates the maximum clock period to the minimum encoder pulse width. The second constraint derives from the decoder operation and is covered in the "Quadrature Decoder" section. It relates the maximum clock period to the minimum encoder state width (T_{es}).

The explanation of constraint one above is as follows: It takes a minimum of four positive clock transitions for a new logic level on either CHA or CHB to propagate through their respective filters, but the signal only needs to be stable for three consecutive rising clock edges (See Figure 7). This means that the minimum encoder pulse width (T_e) on each channel must be $\geq 3T_{CLK}$, where T_{CLK} is the period of the clock.

In the presence of noise, the filter will require that $3T_{CLK}$ be less than T_e, since noise pulses will interrupt the required three consecutive constant level samples necessary for the filter to accept a new input level. In general, the types of noise that this filter will deal with will derive from the rotating system, i.e., motor noise, capacitively coupled level changes from other encoder channels, etc. As such, these noise sources will be periodic in nature and proportional to the encoder frequency. Design for noise of this type is discussed later in the "Filter Optimization" section.

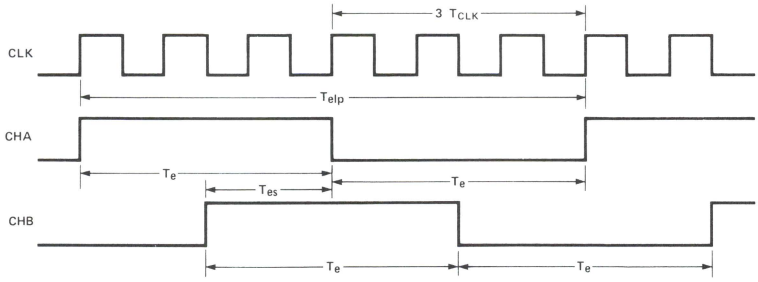


Figure 7. Minimum Encoder Pulse Width with Respect to T_{CLK}

In addition to problems with noise, other common signal problems enter into the determination of the maximum T_{CLK} for each application. The following quadrature signal aberrations can all be accounted for by designing with short enough T_{CLK} to accommodate the reduction of the effective encoder pulse width:

1) non-ideal encoder rise and fall times,
2) asymmetric pulses,
3) short (< 180 electrical degrees) pulses.

Designing for these non-ideal signals is discussed later in the "Filter Optimization" section.

QUADRATURE DECODER

The Quadrature Decoder section samples the outputs from the CHA and CHB filters. Sampling occurs on the rising clock edge. The Decoder Section observes changes in these outputs, and, on the rising clock edge, it outputs two signals to the position counter. These signals specify when to count and in which direction (up or down).

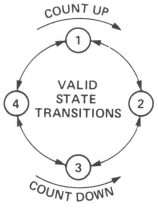
Encoder state changes are detected by comparing the previous sampled state to the current sampled state. If the two are different, the counter section is signaled to count on the next rising clock edge. Count direction (up or down) is also determined by observing the previous and current states, as shown in the quadrature state transition diagram (figure 8). An illegal state transition, caused by a faulty encoder or noises severe enough to pass the filter, will produce a count but in an undefined direction.

The second constraint on the relationship between T_{CLK} and the input quadrature signal, as previously mentioned in the "Digital Filter" section, is the requirement by the 4x decoder for at least one positive clock transition to occur during each quadrature state to detect the state. This constraint is satisfied if: $T_{es} > T_{CLK}$, where T_{es} is the time interval corresponding to the shortest state width at the maximum system velocity.

The combination of the following two errors must be examined in light of the minimum state width constraint to ensure proper operation of the decoder section:

1) Phase shift deviations from 90 electrical degrees between the CHA and CHB signals;
2) Pulse width errors resulting in T_e shorter than 180 electrical degrees in either or both CHA and CHB.

Design for these conditions is discussed in the "Filter Optimization" section.



CHA	CHB	STATE
1	0	1
1	1	2
0	1	3
0	0	4

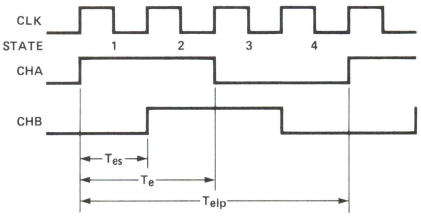


Figure 8. Elements of 4x Quadrature Decoding

POSITION COUNTER

This section consists of a 12-bit binary up/down counter which counts on rising clock edges as specified by the Quadrature Decode Section. All twelve bits of data are passed to the position data latch. The system can use this count data in three ways:

A. System total range is ≤12 bits, so the count represents "absolute" position.

B. The system is cyclic with ≤12 bits of count per cycle, $\overline{RST}$ is used to reset the counter every cycle, and the system uses the data to interpolate within the cycle.

C. System count is >12 bits, so the count data is used as a relative or incremental position input for a system computation of absolute position.

In case C above, counter rollover occurs. In order to prevent loss of position information, the processor must read the outputs of the HCTL-2000 at intervals shorter than 512 times the minimum encoder line period. This minimum line period (T_{elp}) corresponds to the maximum encoder velocity of the design. Two's complement arithmetic is normally used to compute position from these periodic position updates.

POSITION DATA LATCH

This section is a 12-bit latch which captures the position counter output data on each rising clock edge, except when its inputs are disabled by the inhibit logic section during two-byte read operations. The output data is passed to the bus interface section. The latch is cleared asynchronously by the $\overline{RST}$ signal. When active, a signal from the inhibit logic section prevents new data from being captured by the latch, keeping the data stable while successive byte-reads are made through the bus interface section.

BUS INTERFACE

The bus interface section consists of a 16 to 8 line multiplexer and an 8 bit, three-state output buffer. The multiplexer allows independent access to the low and high bytes of the position data latch output. Since the latch is only twelve bits wide, the upper four bits of the high byte are internally set to zero. The SEL and $\overline{OE}$ signals determine which byte is output and whether or not the output bus is in the high-Z state, respectively.

INHIBIT LOGIC

The Inhibit Logic Section samples the $\overline{OE}$ and SEL signals on the falling edge of the clock and, in response to certain conditions (see Figure 9 below), inhibits the position data latch. The $\overline{RST}$ signal asynchronously clears the inhibit logic, enabling the latch.

STEP	SEL	$\overline{OE}$	CLK	INHIBIT SIGNAL	ACTION
1	L	L	↓	1	SET INHIBIT; READ HIGH BYTE
2	H	L	↓	1	READ LOW BYTE; STARTS RESET
3	X	H	↓	0	COMPLETES INHIBIT LOGIC RESET

Figure 9. Two Byte Read Sequence

While the HCTL-2000 can be used with any microprocessor, the Bus Interface and Inhibit Logic sections have been optimized for use with microprocessors similar to the Motorola 6801. The 6801 has a double-byte fetch instruction (LDD) which produces two consecutive fetch cycles on the bus. In the correct interface configuration, the first cycle inhibits the position data latch and reads the high data byte, and the second cycle reads the low byte and resets the inhibit logic. A version of this configuration is illustrated in Figure 14.

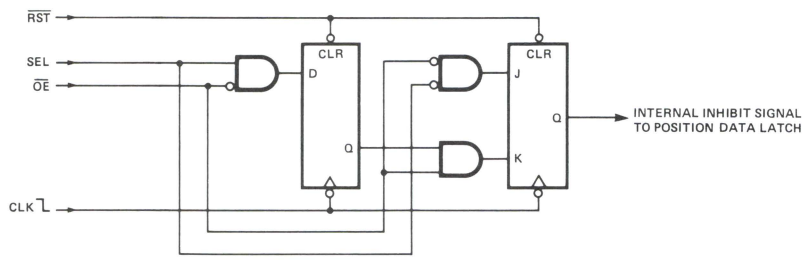


Figure 10. Simplified Inhibit Logic

Filter Optimization

System design with the HCTL-2000 will require the user to optimize its clock period for encoding errors and line noise on the CHA and CHB inputs. In the absence of noise this optimization is simplified. The critical encoding errors, minimum pulse width and minimum state width, occur at the maximum designed system operating velocity. Input noise can be caused by motor electromagnetic interference, channel cross coupling, etc. The HCTL-2000 input filter interacts with encoding errors and noise to form the major system design constraints. This section will illustrate system design techniques and will present guidelines useful in implementing the HCTL-2000.

The discussion that follows will make use of the definitions listed below:

T_{nf} = The fundamental period characteristic of a periodic noise source
T_{CLK} = Period of HCTL-2000 clock input signal
T_{mn} = Maximum pulse duration of encoder noise
$T_{emin} = T_{e(min)}$ = Minimum encoder line pulse width including encoder errors
$T_{esmin} = T_{es(min)}$ = Minimum encoder statewidth including encoder errors
T_{elpmin} = Period of maximum designed encoder line frequency
RPM = Maximum designed operating speed of the encoder in revolutions per minute
N = Encoder line count = Number of encoder counts per revolution
K1 = 60 sec./min.

ENCODING ERRORS

Design for quadrature signal errors proceeds as follows for an ideal quadrature signal, i.e. all errors = 0:

T_{elp} = 360° e = defined as one electrical cycle in electrical degrees (1)

$T_e = 1/2T_{elp}$ = 180° e ideal pulse width (2)

$T_{es} = 1/4T_{elp} = 1/2\ T_e$ = 90° e, ideal state width (3)

In a real system there are quadrature signal errors, where these errors are:

ΔP = Maximum encoder pulse width error in °e, as a deviation from the ideal pulse width of 180° e

ΔS = Maximum state width error in °e, as a deviation from the ideal state width of 90° e

The worst cases for pulse width and state width errors in terms of time intervals will occur at the maximum designed system operating velocity. These errors are typically available from encoder manufacturer's data sheets.

$$T_{elpmin} = \frac{K1}{(RPM)\ (N)} \quad (4)$$

$$T_{emin} = \left(\frac{180 - |\Delta P|}{360}\right) T_{elpmin} \quad (5)$$

$$T_{esmin} = \left(\frac{90 - |\Delta S|}{360}\right) T_{elpmin} \quad (6)$$

NOISE

In the absence of noise, the system design reduces to case A in Table 6. In the presence of noise, cases B through E describe the types of noise for which the above filters are effective. Normal techniques for reducing noise on CHA and CHB inputs may be required to reduce this noise to a level that can be handled by the input filters.

Noise that can be filtered by the HCTL-2000 input filters is noise where $T_{nf} > T_{esmin}$ and $T_{mn} < 2T_{CLK}$. This noise can be subdivided into four categories, each having different design constraints. These categories are differentiated by the pulse width of noise on the individual encoder channels.

Dependant channel noise, as below in case B and C in Table 6, is noise where the superposition of noise from both encoder channels does not display a period shorter than the minimum state width:

$$T_{nf} > T_{esmin}.$$

The graphic analysis of the effect of this type of noise upon the filter operation is illustrated in Figure 11.

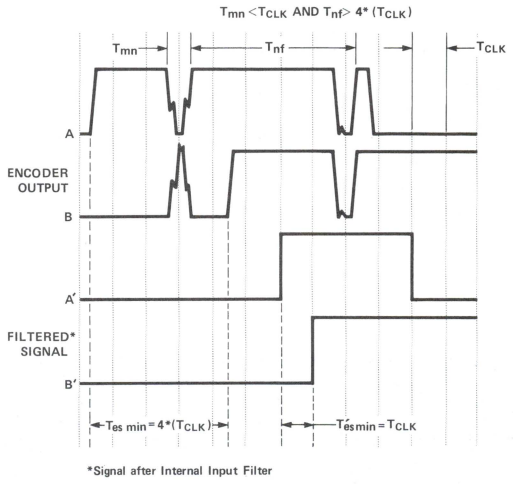
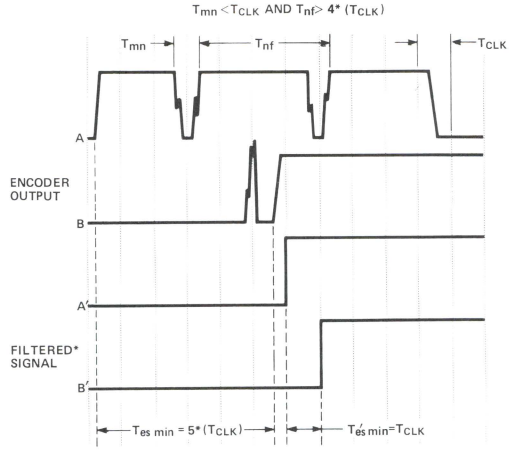


Figure 11. Noise is Encoder Channel Dependent

Independant channel noise, as in case D and E in Table 6, is such that the noise on each channel is independant of the noise on the other channel. The period of the noise on each channel must satisfy the condition:

$$T_{nf} > T_{esmin}$$

independantly. The graphic analysis of the effect of this type of noise on the filter operation is illustrated in Figure 12.



*Signal after Internal Input Filter

Figure 12. Noise is Encoder Channel Independent

The set of design rules that are presented in Table 6 can be derived by examination of Figures 11 and 12, and the following constraints:

a) The encoder output signals must stay at a logic level for a minimum of three consecutive clock pulses before the HCTL-2000 recognizes the logic level change: $T_{emin} > 3T_{CLK}$.

b) After acceptance by the HCTL-2000 input filtering section, a state must exist for a minimum of T_{CLK} to be recognized by the internal logic.

c) The minimum encoded pulse width must be greater than twice the minimum state width: $T_{emin} > 2T_{esmin}$.

d) The minimum clock period must be greater than 255 ns, which is the minimum clock period for which the HCTL-2000 is guaranteed to operate over the entire specified operating temperature range.

FILTER DESIGN EXAMPLES

Given the above rules, we can calculate the design parameters for a typical high performance motor loop as follows:

Where RPM = 3600 rev/min.
N = 1000 counts/rev.
$\Delta P = \pm 48°e$
$\Delta S = \pm 60°e$
at 60° C, $1/T_{elpmin} = 60kHz$

Then the following calculation accounts for signal errors:

$$T_{elpmin} = \left(\frac{K1}{(RPM)(N)}\right) = \frac{60}{(3600)(1000)} \quad \text{from eq. 4}$$

$$= 16667 \text{ ns}$$

$$T_{emin} = \left(\frac{180 - |\Delta P|}{360}\right) T_{elpmin}$$

$$= \left(\frac{180 - 48}{360}\right)(16667 \text{ ns}) \quad \text{from eq. 5}$$

$$= 6111 \text{ ns}$$

$$T_{esmin} = \left(\frac{90 - |\Delta S|}{360}\right) T_{elpmin}$$

$$= \left(\frac{90 - 60}{360}\right)(16667 \text{ ns}) \quad \text{from eq. 6}$$

$$= 1389 \text{ ns}$$

If the noise is as in case B of Table 6, we can use the above to evaluate the system.

For the condition of noise such that $T_{mn} < 260$ ns:

$$T_{CLK} > 260 \text{ ns}$$

$$255 \text{ ns} \leq T_{CLK} < \frac{T_{esmin}}{4}$$

$$\frac{T_{esmin}}{4} = \frac{1389}{4} = 347 \text{ ns}$$

Thus,

$$255 \text{ ns} \leq T_{CLK} < 347 \text{ ns}$$

Similar calculations can be performed to design the filter for the specifics of each system.

Table 6. Summary of Filter Design Rules for the HCTL-2000

Case	Noise Relationship	General Conditions	Pulse Width Constraint	Clock Period Design Criteria
A	No noise on CHA or CHB	$T_{emin} > 2T_{esmin}$	$T_{clk} < T_{esmin}$	$255ns \leq T_{clk} < (1/3)T_{emin}$
B	Superposition of noise on CHA or CHB	$T_{esmin} > T_{nf}$ $T_{emin} > 2T_{esmin}$	$T_{clk} > T_{mn} > 0$	$255ns \leq T_{clk} < (1/4)T_{esmin}$
C	Superposition of noise on CHA or CHB	$T_{esmin} > T_{nf}$ $T_{emin} > 2T_{esmin}$	$2T_{clk} > T_{mn} \geq T_{clk}$	$255ns \leq T_{clk} < (1/5)T_{esmin}$
D	Noise on CHA or on CHB Independent of each other	$T_{esmin} > T_{nf}$ $T_{emin} > 2T_{esmin}$	$T_{clk} > T_{mn} > 0$	$255ns \leq T_{clk} < (1/5)T_{esmin}$
E	Noise on CHA or on CHB Independent of each other	$T_{esmin} > T_{nf}$ $T_{emin} > 2T_{esmin}$	$2T_{clk} > T_{mn} \geq T_{clk}$	$255ns \leq T_{clk} < (1/7)T_{esmin}$

Interfacing the HCTL-2000: General

The 12 bit latch and inhibit logic on the HCTL-2000 allows access to 12 bits of count with an 8 bit bus. When only 8 bits of count are required, a simple 8 bit (1 byte) mode is available by holding SEL high continously. This disables the inhibit logic. $\overline{OE}$ provides control of the tri-state bus, and read timing is per Figures 3 and 4.

For proper operation of the inhibit logic during a two-byte read, $\overline{OE}$ and SEL must be synchronous with CLK due to the falling edge sampling of $\overline{OE}$ and SEL.

The internal inhibit logic on HCTL-2000 inhibits the transfer of data from the counter to the position data latch during the time that the latch outputs are being read. The inhibit logic allows the microprocessor to first read the high order 4 bits from the latch and then read the low order 8 bits from the latch. Meanwhile, the counter can continue to keep track of the quadrature states from the CHA and CHB input signals.

Figure 10 shows a logic diagram of the inhibit logic circuit. The operation of the circuitry is illustrated in the read timing shown in Figure 13.

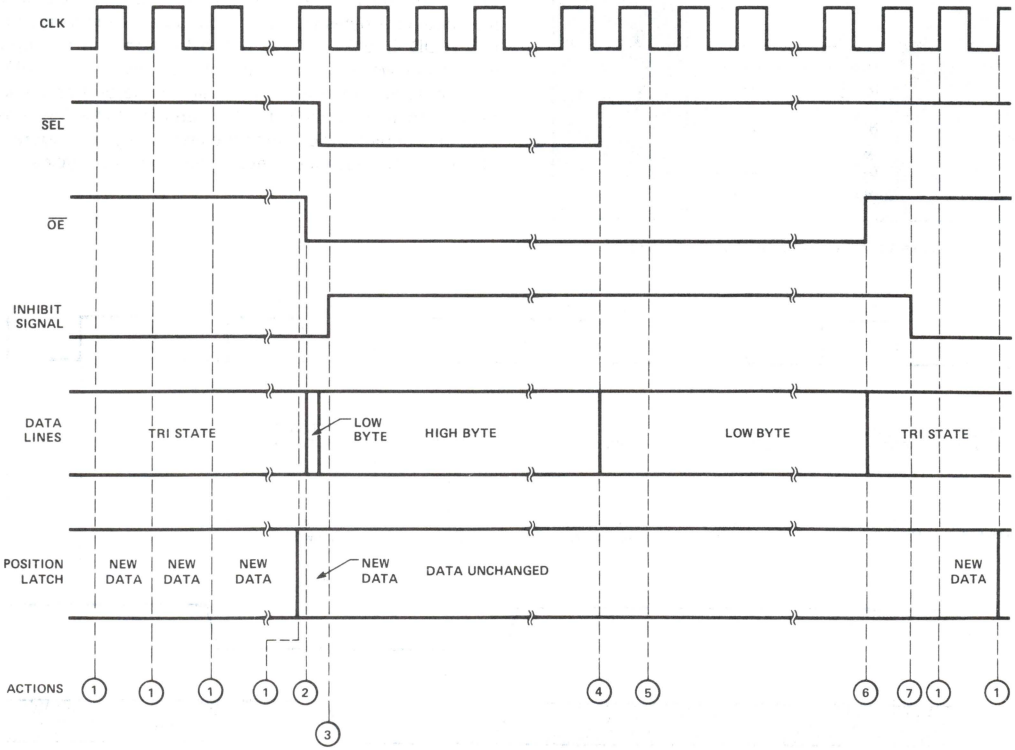


Figure 13. Internal Inhibit Logic Timing

ACTIONS

1. On the rising edge of the clock, counter data is transferred to the position data latch, provided the inhibit signal is low.
2. When $\overline{OE}$ goes low, the outputs of the multiplexer are enabled onto the data lines. If SEL is low, then the high order data bytes are enabled onto the data lines. If SEL is high, then the low order data bytes are enabled onto the data lines.
3. When the HCTL-2000 detects a low on $\overline{OE}$ and SEL during a falling clock edge, the internal inhibit signal is activated. This blocks new data from being transferred from the counter to the position data latch.
4. When SEL goes high, the data outputs change from high byte to low byte.
5. The first reset condition for the inhibit logic is met when the HCTL-2000 detects a logic high on SEL and a logic low on $\overline{OE}$ during a falling clock edge.
6. When $\overline{OE}$ goes high, the data lines change to a high impedance state.
7. To complete the reset of the inhibit logic, after the first reset condition has been met, the HCTL-2000 needs to detect a logic high on $\overline{OE}$ during a falling clock edge.

Interfacing the HCTL-2000 to a Motorola 6801

This interface method provides the minimum part count when the 6801 is operated in "MODE 5". A typical 6801 circuit is shown in Figure 14. In Figure 14, the 74LS138 address decoder can be eliminated if the HCTL-2000 is the only occupant of Port 4.

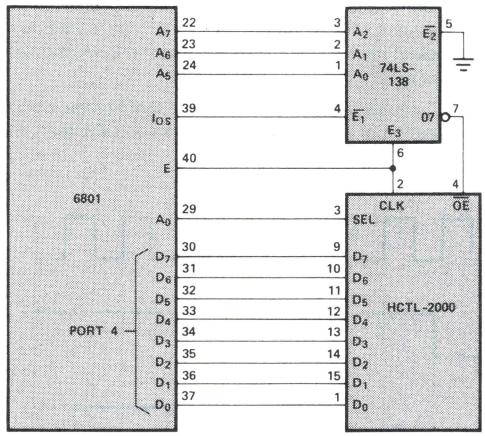


Figure 14. A Circuit to Interface to the 6801

The processor clock output (E) is used to clock the HCTL-2000 as well as the address decoder. One of the address decoder outputs drives the $\overline{OE}$ input. This results in HCTL-2000 counter data being enabled onto the bus whenever an external memory access is made to the HCTL-2000. This example assumes the address assigned to the HCTL-2000 high byte is an even address. The least significant address bit is connected to the SEL input. It determines which data byte is output. When A0 on the decoder equals 0 the chip selects the high byte, and when A0 equals 1, the chip selects the low byte. This configuration allows the 6801 to read both data bytes with a single double-byte fetch instruction (LDD E, 01XX). The LDD instruction is a five cycle instruction which reads external memory location 01XX and stores the high order byte in accumulator A and reads external memory location 01XX +1 and stores the low order byte in accumulator B during the last two cycles. Figure 15 illustrates the sequence of events during all five cycles.

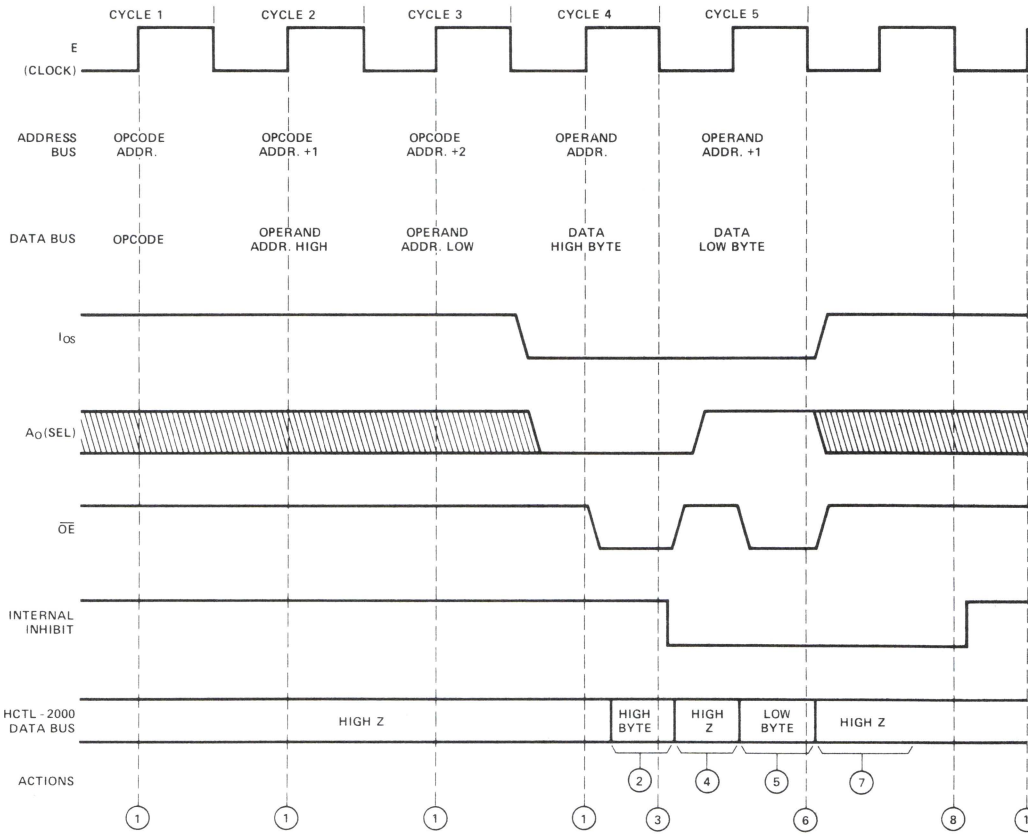


Figure 15. Interface Timing for the 6801 LDD E

ACTIONS

1. E is the microprocessor clock output. On the rising edge of E, if the internal inhibit is not active, then new data is transferred from the internal counter to the position data latch.
2. An even address output from the 6801 has caused SEL to go low. E goes high which causes the address decoder output for the HCTL-2000 $\overline{OE}$ input to go low. This causes the HCTL-2000 to output the high byte of the position data latch.
3. The 6801 reads the data bus on the falling edge of E, storing the high order data byte in accumulator A. The chip detects that $\overline{OE}$ and SEL are low on the falling edge of E and activates the internal inhibit signal. The position data latch is inhibited and data cannot be transferred from the internal counter to the latch.
4. E is now low, so the address decoder output is disabled and $\overline{OE}$ goes high. The 6801 increments the address, so SEL goes high. The position data latch is still inhibited.
5. The address decoder is enabled after E goes high, so $\overline{OE}$ goes low and the low data byte is enabled onto the bus.
6. The 6801 reads the data bus on the falling edge of E, storing the low order data byte in accumulator B. The chip detects that $\overline{OE}$ is low and SEL is high on the falling edge of E, so the first inhibit-reset condition is met.
7. E is now low, so the address decoder is disabled, causing $\overline{OE}$ to go high and the data lines to go to the high impedence state. The 6801 continues its instruction execution, and the state of SEL is indeterminate.
8. The HCTL-2000 detects $\overline{OE}$ is high on the next falling edge of E. This satisfies the second inhibit reset condition so the inhibit signal is reset.

Interfacing the HCTL-2000 to an Intel 8748

The circuit in Figure 15 shows the connections between an HCTL-2000 and an 8748. Data lines D0-D7 are connected to the 8748 bus port. Bits 0 and 1 of port 1 are used to control the SEL and $\overline{OE}$ inputs of the HCTL-2000 respectively. T0 is used to provide a clock signal to the HCTL-2000. The frequency of T0 is the crystal frequency divided by 3. T0 must be enabled by executing the ENT0 CLK instruction after each system reset, but prior to the first encoder position change. An 8748 program which interfaces to the circuit in Figure 16 is given in Figure 17. The resulting interface timing is shown in Figure 18.

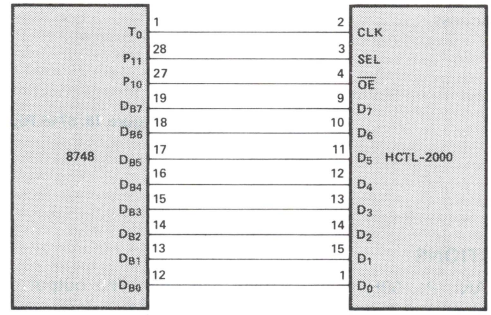


Figure 16. An HCTL-2000 to Intel 8748 Interface

LOC	OBJECT CODE	SOURCE STATEMENTS	
000	99 00	ANL P1, 00H	ENABLE OUTPUT AND OUTPUT HIGHER ORDER BITS
002	08	INS A, BUS	LOAD HIGHER ORDER BITS INTO ACC
003	A8	MOVE R0 A	MOVE DATA TO REGISTER 0
004	89 03	ORL P1, 01H	CHANGE DATA FROM HIGH ORDER TO LOW ORDER BITS
006	08	INS A, BUS	LOAD ORDER BITS INTO AC
008	A9	MOV R1, A	MOVE DATA TO REGISTER 1
009	89 03	ORL P1, 03H	DISABLE OUTPUTS
00B	93	RETR	RETURN

Figure 17. A Typical Program for Reading HCTL-2000 with an 8748

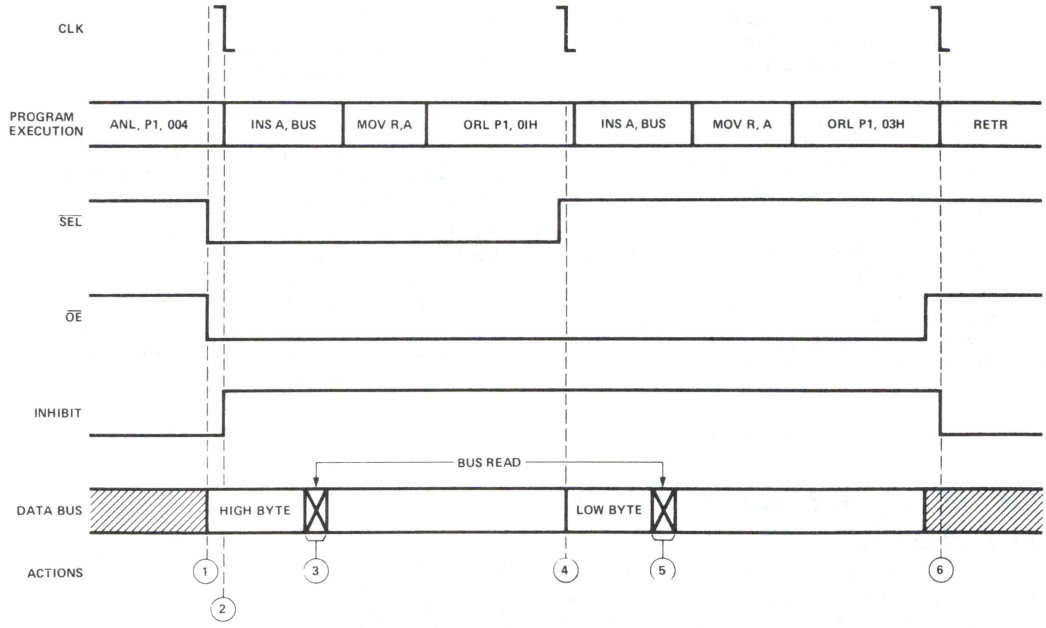


Figure 18. 8748 READ Cycle from Figure 14.

ACTIONS

1. ANL P1, 00H has just been executed. The output of bits 0 and 1 of Port 1 cause SEL and $\overline{OE}$ to be logic low. The data lines output the higher order byte.
2. The HCTL-2000 detects that $\overline{OE}$ and SEL are low on the next falling edge of the CLK and asserts the internal inhibit signal. Data can be read without regard for the phase of the CLK.
3. INS A, BUS has just been executed. Data is read into the 8748.
4. ORL PORT 1, 01H has just been executed. The program sets SEL high and leaves $\overline{OE}$ low by writing the correct values to port 1. The HCTL-2000 responds by outputting the lower byte. The HCTL-2000 detects $\overline{OE}$ is low and SEL is high on the next falling edge of the CLK, and thus, the first inhibit-reset condition is met.
5. INS A, BUS has just been executed. Lower order data bits are read into the 8748.
6. ORL P1, 03H has just been executed. The HCTL-2000 detects $\overline{OE}$ high on the next falling edge of CLK. The program sets $\overline{OE}$ and SEL high by writing the correct values to port 1. This causes the data lines to be tri-stated. This satisfies the second inhibit-reset condition. On the next rising CLK edge new data is transferred from the counter to the position data latch.

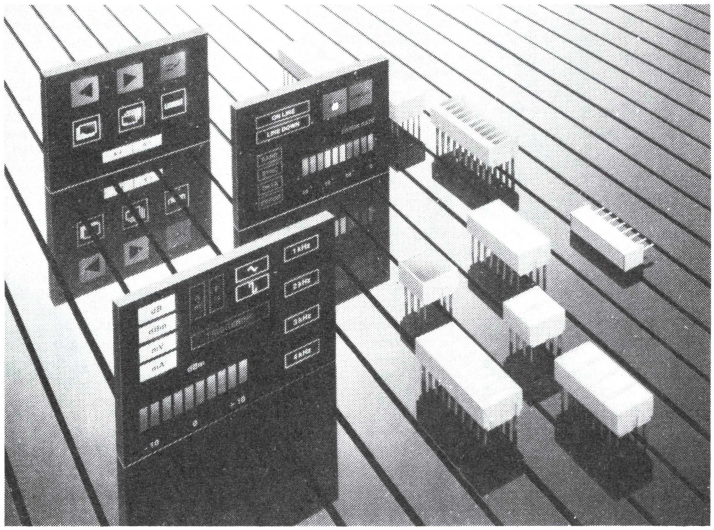
Light Bars and Bar Graph Arrays

- **Light Bars**
- **Bar Graph Arrays**
- **Legends**

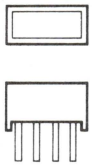
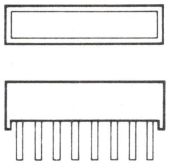
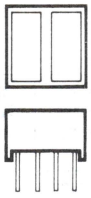
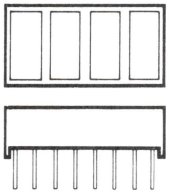
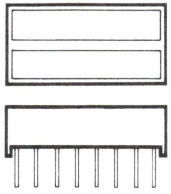
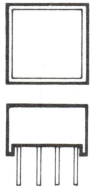
Light Bars and Bar Graph Arrays

LED Light Bars are Hewlett-Packard's innovative solution to fixed message annunciation. The large, uniformly illuminated light emitting surface may be used for backlighting legends or simple indicators. Four distinct colors are offered, AlGaAs red, high efficiency red, yellow, and high performance green with two bicolor combinations (see page 5-15). The AlGaAs Red Light Bars provide exceptional brightness at very low drive currents for those applications where portability and battery backup are important considerations. Each of the eight X-Y stackable package styles offers one, two, or four light emitting surfaces. Along with this family of stackable light bars, HP also provides a single chip light bar for high brightness indication of small areas. Panel Mounts and Legends are also available for all devices.

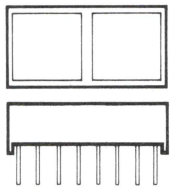
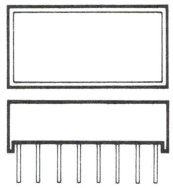
In addition to light bars, HP offers effective analog message annunciation with the 10-element and 101-element LED Bar Graph Arrays. These bar graph arrays eliminate the matching and alignment problems commonly associated with arrays of discrete LED indicators. Each device offers easy to handle packages that are compatible with standard SIP and DIP sockets. The 10-element Bar Graph Array is available in standard red, AlGaAs red, high efficiency red, yellow, and high performance green. The new multicolor 10-element arrays have high efficiency red, yellow and green LEDs in one package. The package is X-Y stackable, with a unique interlock allowing easy end-to-end alignment. The 101-element Bar Graph Array is offered in standard red, high efficiency red and high performanc green with 1% resolution.



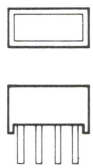
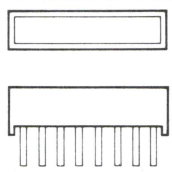
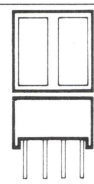
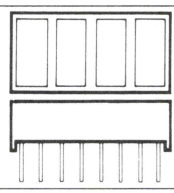
LED Light Bars

Device		Description			Typical Luminous Intensity @ 20 mA	Typical Forward Voltage @ 20 mA	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens			
	HLMP-2300	High Efficiency Red	4 Pin In-Line; 0.100" Centers; 0.400"L x 0.195"W x 0.245"H	Diffused	23 mcd	2.0 V	5-8
	HLMP-2400	Yellow		Diffused	20 mcd	2.1 V	
	HLMP-2500	Green		Green Diffused	25 mcd	2.2 V	
	HLMP-2350	High Efficiency Red	8 Pin In-Line; 0.100" Centers; 0.800"L x 0.195"W x 0.245"H	Diffused	45 mcd	2.0 V	
	HLMP-2450	Yellow		Diffused	38 mcd	2.1 V	
	HLMP-2550	Green		Green Diffused	50 mcd	2.2 V	
	HLMP-2600	High Efficiency Red	8 Pin DIP; 0.100" Centers; 0.400"L x 0.400"W x 0.245"H Dual Arrangement	Diffused	22 mcd	2.0 V	
	HLMP-2700	Yellow		Diffused	18 mcd	2.1 V	
	HLMP-2800	Green		Green Diffused	25 mcd	2.2 V	
	HLMP-2620	High Efficiency Red	16 Pin DIP; 0.100" Centers; 0.800"L x 0.400"W x 0.245"H Quad Arrangement	Diffused	25 mcd	2.0 V	
	HLMP-2720	Yellow		Diffused	18 mcd	2.1 V	
	HLMP-2820	Green		Green Diffused	25 mcd	2.2 V	
	HLMP-2635	High Efficiency Red	16 Pin DIP; 0.100" Centers; 0.800"L x 0.400"W x 0.245"H Dual Bar Arrangement	Diffused	45 mcd	2.0 V	
	HLMP-2735	Yellow		Diffused	35 mcd	2.1 V	
	HLMP-2835	Green		Green Diffused	50 mcd	2.2 V	
	HLMP-2655	High Efficiency Red	8 Pin DIP; 0.100" Centers; 0.400"L x 0.400"W x 0.245"H Square Arrangement	Diffused	43 mcd	2.0 V	
	HLMP-2755	Yellow		Diffused	35 mcd	2.1 V	
	HLMP-2855	Green		Green Diffused	50 mcd	2.2 V	

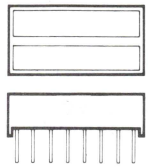
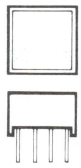
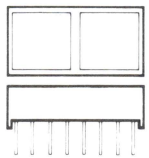
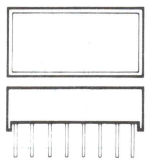
LED Light Bars (Continued)

Device		Description			Typical Luminous Intensity @ 20 mA	Typical Forward Voltage @ 20 mA	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens			
	HLMP-2670	High Efficiency Red	16 Pin DIP; 0.100" Centers; 0.800"L x 0.400"W x 0.245"H Dual Square Arrangement	Diffused	45 mcd	2.0 V	5-8
	HLMP-2770	Yellow		Diffused	35 mcd	2.1 V	
	HLMP-2870	Green		Green Diffused	50 mcd	2.2 V	
	HLMP-2685	High Efficiency Red	16 Pin DIP; 0.100" Centers; 0.800"L x 0.400"W x 0.245"H Single Bar Arrangement	Diffused	80 mcd	2.0 V	
	HLMP-2785	Yellow		Diffused	70 mcd	2.1 V	
	HLMP-2885	Green		Green Diffused	100 mcd	2.2 V	

DH AlGaAs Low Current LED Light Bars

Device		Description			Typical Luminous Intensity @ 3 mA	Typical Forward Voltage @ 3 mA	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens			
	HLCP-A100	AlGaAs Red	4 Pin In-Line; 0.100" Centers; 0.400"L x 0.195"W x 0.240"H	Diffused	7.5 mcd	1.6 V	5-15
	HLCP-B100	AlGaAs Red	8 Pin In-Line; 0.100" Centers; 0.800"L x 0.195"W x 0.240"H	Diffused	15.0 mcd		
	HLCP-D100	AlGaAs Red	8 Pin DIP; 0.100" Centers; 0.400"L x 0.400"W x 0.240"H Dual Arrangement	Diffused	7.5 mcd		
	HLCP-E100	AlGaAs Red	16 Pin DIP; 0.100" Centers; 0.800"L x 0.400"W x 0.240"H Quad Arrangement	Diffused	7.5 mcd		

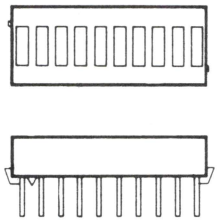
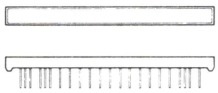
DH AlGaAs Low Current LED Light Bars (Continued)

Device		Description			Typical Luminous Intensity @ 3 mA	Typical Forward Voltage @ 3 mA	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens			
	HLCP-F100	AlGaAs Red	16 Pin DIP; 0.100" Centers; 0.800"L x 0.400"W x 0.240"H Dual Bar Arrangement	Diffused	15.0 mcd	1.6 V	5-15
	HLCP-C100	AlGaAs Red	8 Pin DIP; 0.100" Centers; 0.400"L x 0.400"W x 0.240"H Square Arrangement	Diffused	15.0 mcd		
	HLCP-G100	AlGaAs Red	16 Pin DIP; 0.100" Centers; 0.800"L x 0.400"W x 0.240"H Dual Square Arrangement	Diffused	15.0 mcd		
	HLCP-H100	AlGaAs Red	16 Pin DIP; 0.100" Centers; 0.800"L x 0.400"W x 0.240"H Single Bar Arrangement	Diffused	30.0 mcd		

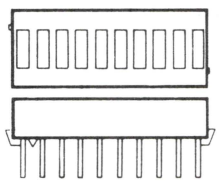
LED Bicolor Light Bars

Device		Description			Typical Luminous Intensity @ 20 mA	Typical Forward Voltage @ 20 mA	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens			
	HLMP-2950	High Efficiency Red/ Yellow	8 Pin DIP; .100" Centers; .400"L x .400"W x .245"H Square Arrangment	Diffused	HER: 20 mcd Yellow: 12 mcd	HER: 2.0 V Yellow: 2.1 V	5-20
	HLMP-2965	High Efficiency Red/ Green		Diffused	HER: 20 mcd Green: 20 mcd	HER: 2.0 V Green: 2.2 V	

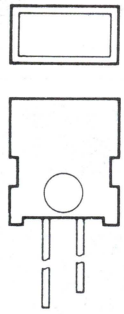
LED Bar Graph Arrays

Device		Description			Typical Luminous Intensity	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens			
	HDSP-4820	Standard Red	20 Pin DIP; .100" Centers; 1.0"L x .400"W x .200"	Diffused	1250 μcd @ 20 mA DC	1.6 V @ 20 mA DC	5-27
	HDSP-4830	High Efficiency Red		Diffused	3500 μcd @ @ 10 mA DC	2.1 V @ 20 mA DC	
	HDSP-4840	Yellow		Diffused	1900 μcd @ 10 mA DC	2.2 V @ 20 mA DC	
	HDSP-4850	High Performance Green		Green Diffused	1900 μcd @ 10 mA DC	2.1 V @ 10 mA DC	
	HDSP-4832	Multicolor		Diffused	1900 μcd @ 10 mA DC		
	HDSP-4836	Multicolor		Diffused	1900 μcd @ 10 mA DC		
	HDSP-8820	Standard Red	22 Pin DIP; .100" Centers; 4.16"L x .390"W x .236"H	Red, Non-Diffused	20 μcd @ 100 mA Pk: 1 of 110 D.F.	1.7 V @ 100 mA Pk: 1 of 110 D.F.	5-33
	HDSP-8825	High Efficiency Red		Clear	175 μcd @ 100 mA Pk: 1 of 110 D.F.	2.3 V @ 100 mA Pk: 1 of 110 D.F.	
	HDSP-8835	High Performance Green		Clear	175 μcd @ 100 mA Pk: 1 of 110 D.F.	2.3 V @ 100 mA Pk: 1 of 110 D.F.	

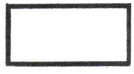
DH AlGaAs Low Current 10-Element Bar Graph Arrays

Device		Description			Typical Luminous Intensity	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens			
	HLCP-J100	AlGaAs Red	20 Pin DIP; .100" Centers; 1.0"L x .400"W x .200"	Diffused	1000 μcd @ 1 mA	1.6 V @ 1 mA	5-41

Single Chip LED Light Bar

Device		Description			Typical Luminous Intensity	2Θ 1/2	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens				
	HLMP-T200	High Efficiency Red (626 nm)	One Chip LED Light Bar	Tinted Diffused	4.8 mcd @ 20 mA	100°	2.2 V @ 20 mA	5-45
	HLMP-T300	Yellow (585 nm)			6.0 mcd @ 20 mA		2.2 V @ 20 mA	
	HLMP-T400	Orange (608 nm)			4.8 mcd @ 20 mA		2.2 V @ 20 mA	
	HLMP-T500	Green (569 nm)			6.0 mcd @ 20 mA		2.3 V @ 20 mA	

Panel and Legend Mounts for LED Light Bars

Device		Corresponding Light Bar Module Part Number	Page No.
Package Outline Drawing	Part No.		
	HLMP-2598	HLMP-2350, -2450, -2550, HLCP-B100	5-49
	HLMP-2599	HLMP-2300, -2400, -2500, HLCP-A100	
	HLMP-2898	HLMP-2600, -2700, -2800 -2655, -2755, -2855 -2950, -2965, HLCP-C100, -D100	
	HLMP-2899	HLMP-2620, -2720, -2820, -2635, -2735, -2835 -2670, -2770, -2870 -2685, -2785, -2885 HLCP-E100, -F100, -G100, -H100	

Special Options

Description	Option Code	Applicable Part Number HLMP-	Page No.
Legends	L00, L01, L03, L04 L00, L01, L03, L06, L04 L00, L01, L02, L03, L04, L05, L06	2300, 2400, 2500, HLCP-A100 2655, 2755, 2855, HLCP-C100 2685, 2785, 2885, HLCP-H100	5-51
Intensity Selected	S02	2300, 2400, 2500, 2635, 2735, 2835 2350, 2450, 2550, 2655, 2755, 2855 2600, 2700, 2800, 2670, 2770, 2870 2620, 2720, 2820, 2685, 2785, 2885	5-53

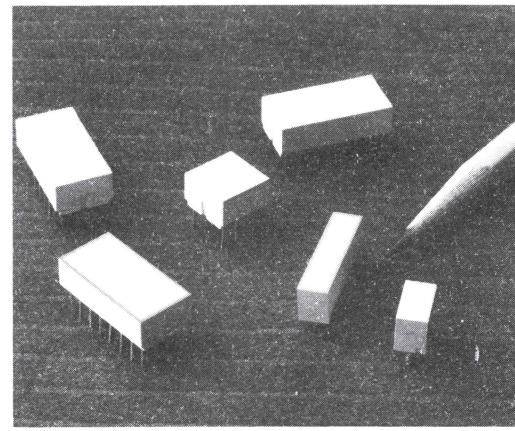
HEWLETT PACKARD

LED LIGHT BARS

HIGH EFFICIENCY RED HLMP-2300/-2600 SERIES
YELLOW HLMP-2400/-2700 SERIES
HIGH PERFORMANCE GREEN HLMP-2500/-2800 SERIES

Features

- LARGE, BRIGHT, UNIFORM LIGHT EMITTING AREAS
  Approximately Lambertian Radiation Pattern
- CHOICE OF THREE COLORS
- CATEGORIZED FOR LIGHT OUTPUT
- YELLOW AND GREEN CATEGORIZED FOR DOMINANT WAVELENGTH
- EXCELLENT ON-OFF CONTRAST
- EASILY MOUNTED ON P.C. BOARDS OR INDUSTRY STANDARD SIP/DIP SOCKETS
- MECHANICALLY RUGGED
- X-Y STACKABLE
- FLUSH MOUNTABLE
- CAN BE USED WITH PANEL AND LEGEND MOUNTS
- LIGHT EMITTING SURFACE SUITABLE FOR LEGEND ATTACHMENT PER APPLICATION NOTE 1012
- SUITABLE FOR MULTIPLEX OPERATION
- I.C. COMPATIBLE



Applications

- BUSINESS MACHINE MESSAGE ANNUNCIATORS
- TELECOMMUNICATIONS INDICATORS
- FRONT PANEL PROCESS STATUS INDICATORS
- PC BOARD IDENTIFIERS
- BAR GRAPHS

Description

The HLMP-2300/-2400/-2500/-2600/-2700/-2800 series light bars are rectangular light sources designed for a variety of applications where a large, bright source of light is required. These light bars are configured in single-in-line and dual-in-line packages that contain either single or segmented light emitting areas. The -2300/-2400/-2600/-2700 series devices utilize LED chips which are made from GaAsP on a transparent GaP substrate. The -2500/-2800 series devices utilize chips made from GaP on a transparent GaP substrate.

Selection Guide

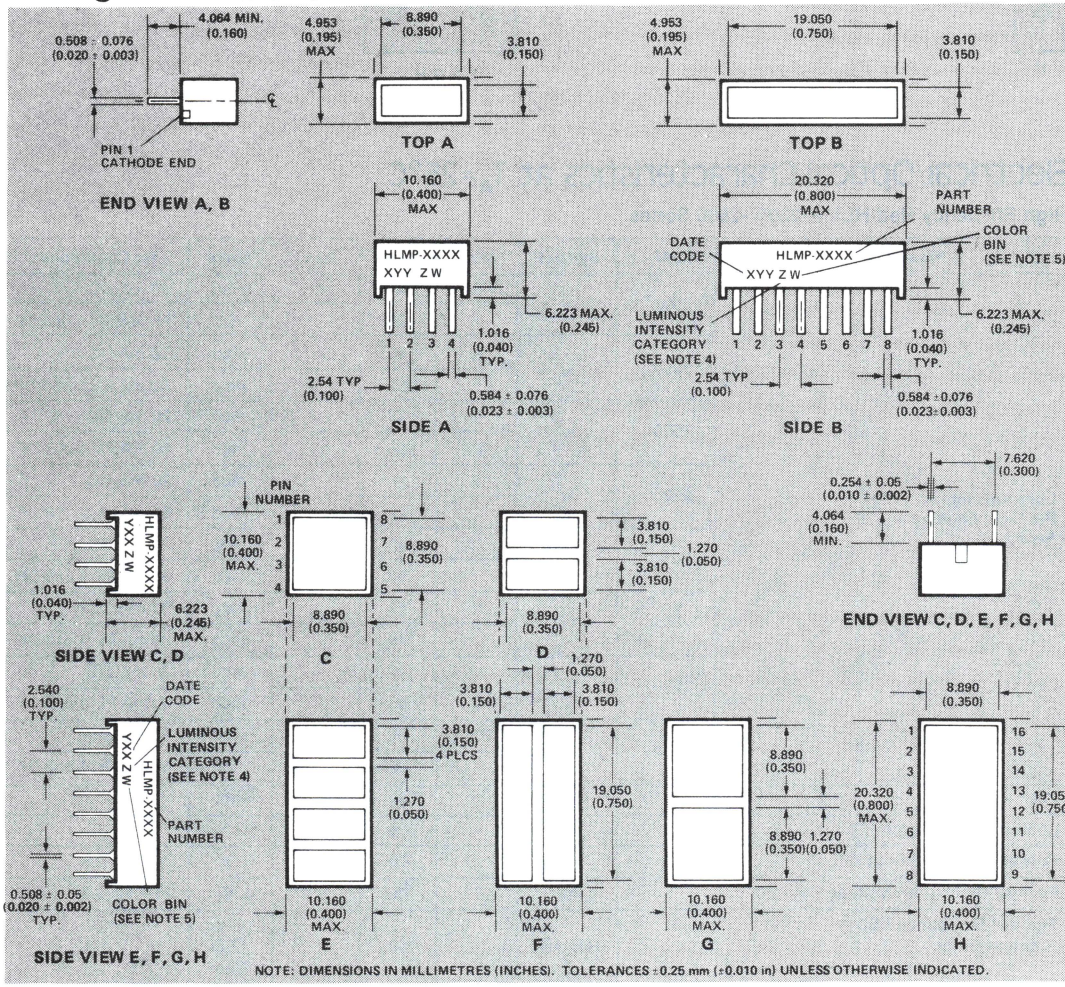
Light Bar Part Number HLMP-			Size of Light Emitting Areas	Number of Light Emitting Areas	Package Outline		Corresponding Panel and Legend Mount Part No. HLMP-
High Efficiency Red	Yellow	Green					
2300	2400	2500	8.89 mm x 3.81 mm (0.350 in. x 0.150 in.)	1	A		2599
2350	2450	2550	19.05 mm x 3.81 mm (0.750 in. x 0.150 in.)	1	B		2598
2600	2700	2800	8.89 mm x 3.81 mm (0.350 in. x 0.150 in.)	2	D		2698
2620	2720	2820	8.89 mm x 3.81 mm (0.350 in. x 0.150 in.)	4	E		2899
2635	2735	2835	3.81 mm x 19.05 mm (0.150 in. x 0.750 in.)	2	F		2899
2655	2755	2855	8.89 mm x 8.89 mm (0.350 in. x 0.350 in.)	1	C		2898
2670	2770	2870	8.89 mm x 8.89 mm (0.350 in. x 0.350 in.)	2	G		2899
2685	2785	2885	8.89 mm 19.05 mm (0.350 in. x 0.750 in.)	1	H		2899

Absolute Maximum Ratings

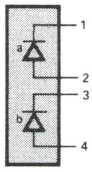
Parameter	HLMP-2300/ -2600 Series	HLMP-2400/ -2700 Series	HLMP-2500/ -2800 Series
Average Power Dissipation per LED Chip[1]	135 mW	85 mW	135 mW
Peak Forward Current per LED Chip, $T_A = 50°C$ (Maximum Pulse Width = 2 ms[2])	90 mA	60 mA	90 mA
Time Average Forward Current per LED Chip, Pulsed Conditions[2]	25 mA $T_A = 25°C$	20 mA $T_A = 50°C$	25 mA $T_A = 25°C$
DC Forward Current per LED Chip, $T_A = 50°C$[3]	30 mA	25 mA	30 mA
Reverse Voltage per LED Chip	6V		
Operating Temperature Range	-40°C to +85°C		-20°C to +85°C
Storage Temperature Range	-40°C to +85°C		
Lead Soldering Temperature 1.6 mm (1/16 inch) Below Seating Plane	260°C for 3 seconds		

NOTES: 1. For HLMP-2300/-2500/-2600/-2800 series, derate above T_A=25°C at 1.8 mW/°C per LED chip. For HLMP-2400/-2700 series, derate above T_A=50°C at 1.8 mW/°C per LED chip. See Figure 2.
2. See Figure 1 to establish pulsed operating conditions.
3. For HLMP-2300/-2500/-2600/-2800 series, derate above T_A =50°C at 0.50 mA/°C per LED chip. For HLMP-2400/-2700 series, derate above T_A =60°C at 0.50 mA/°C per LED chip. See Figure 3.

Package Dimensions

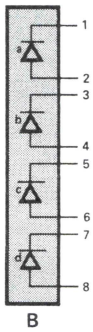


Internal Circuit Diagrams

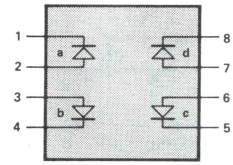


A

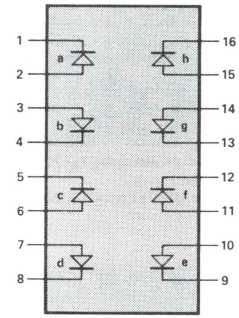
PIN	PIN FUNCTION A -2300/-2400 -2500	PIN FUNCTION B -2350/-2450 -2550
1	Cathode — a	Cathode — a
2	Anode — a	Anode — a
3	Cathode — b	Cathode — b
4	Anode — b	Anode — b
5		Cathode — c
6		Anode — c
7		Cathode — d
8		Anode — d



B



C,D



E,F,G,H

PIN	PIN FUNCTION C, D	PIN FUNCTION E, F, G, H
1	CATHODE a	CATHODE a
2	ANODE a	ANODE a
3	ANODE b	ANODE b
4	CATHODE b	CATHODE b
5	CATHODE c	CATHODE c
6	ANODE c	ANODE c
7	ANODE d	ANODE d
8	CATHODE d	CATHODE d
9		CATHODE e
10		ANODE e
11		ANODE f
12		CATHODE f
13		CATHODE g
14		ANODE g
15		ANODE h
16		CATHODE h

Electrical/Optical Characteristics at T_A=25°C

High Efficiency Red HLMP-2300/-2600 Series

Parameter	HLMP-	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity[4] Per Light Emitting Area	2300	I_V	6	23		mcd	20 mA DC
				26		mcd	60 mA Pk: 1 of 3 DF
	2350	I_V	13	45		mcd	20 mA DC
				52		mcd	60 mA Pk: 1 of 3 DF
	2600	I_V	6	22		mcd	20 mA DC
				25		mcd	60 mA Pk: 1 of 3 DF
	2620	I_V	6	25		mcd	20 mA DC
				29		mcd	60 mA Pk: 1 of 3 DF
	2635	I_V	13	45		mcd	20 mA DC
				52		mcd	60 mA Pk: 1 of 3 DF
	2655	I_V	13	43		mcd	20 mA DC
				49		mcd	60 mA Pk: 1 of 3 DF
	2670	I_V	13	45		mcd	20 mA DC
				52		mcd	60 mA Pk: 1 of 3 DF
	2685	I_V	22	80		mcd	20 mA DC
				92		mcd	60 mA Pk: 1 of 3 DF
Peak Wavelength		λ_{peak}		635		nm	
Dominant Wavelength[5]		λ_d		626		nm	
Forward Voltage Per LED		V_F		2.0	2.6	V	I_F = 20 mA
Reverse Breakdown Voltage Per LED		V_{BR}	6	15		V	I_R = 100μA
Thermal Resistance LED Junction-to-Pin		$R\theta_{J-PIN}$		150		°C/W/ LED Chip	

Yellow HLMP-2400/-2700 Series

Parameter	HLMP-	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity[4] Per Light Emitting Area	2400	I_V	6	20		mcd	20 mA DC
				24		mcd	60 mA Pk: 1 of 3 DF
	2450	I_V	13	38		mcd	20 mA DC
				46		mcd	60 mA Pk: 1 of 3 DF
	2700	I_V	6	18		mcd	20 mA DC
				22		mcd	60 mA Pk: 1 of 3 DF
	2720	I_V	6	18		mcd	20 mA DC
				22		mcd	60 mA Pk: 1 of 3 DF
	2735	I_V	13	35		mcd	20 mA DC
				43		mcd	60 mA Pk: 1 of 3 DF
	2755	I_V	13	35		mcd	20 mA DC
				43		mcd	60 mA Pk: 1 of 3 DF
	2770	I_V	13	35		mcd	20 mA DC
				43		mcd	60 mA Pk: 1 of 3 DF
	2785	I_V	26	70		mcd	20 mA DC
				85		mcd	60 mA Pk: 1 of 3 DF
Peak Wavelength		λ_{peak}		583		nm	
Dominant Wavelength[5]		λ_d		585		nm	
Forward Voltage Per LED		V_F		2.1	2.6	V	I_F = 20 mA
Reverse Breakdown Voltage Per LED		V_{BR}	6	15		V	I_R = 100 μA
Thermal Resistance LED Junction-to-Pin		$R\theta_{J-PIN}$		150		°C/W/ LED Chip	

High Performance Green HLMP-2500/-2800 Series

Parameter	HLMP-	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity[4] Per Light Emitting Area	2500	I_V	5	25		mcd	20 mA DC
				28		mcd	60 mA Pk: 1 of 3 DF
	2550	I_V	11	50		mcd	20 mA DC
				56		mcd	60 mA Pk: 1 of 3 DF
	2800	I_V	5	25		mcd	20 mA DC
				28		mcd	60 mA Pk: 1 of 3 DF
	2820	I_V	5	25		mcd	20 mA DC
				28		mcd	60 mA Pk: 1 of 3 DF
	2835	I_V	11	50		mcd	20 mA DC
				56		mcd	60 mA Pk: 1 of 3 DF
	2855	I_V	11	50		mcd	20 mA DC
				56		mcd	60 mA Pk: 1 of 3 DF
	2870	I_V	11	50		mcd	20 mA DC
				56		mcd	60 mA Pk: 1 of 3 DF
	2885	I_V	22	100		mcd	20 mA DC
				111		mcd	60 mA Pk: 1 of 3 DF
Peak Wavelength		λ_{peak}		565		nm	
Dominant Wavelength[5]		λ_d		572		nm	
Forward Voltage Per LED		V_F		2.2	2.6	V	I_F = 20 mA
Reverse Breakdown Voltage Per LED		V_{BR}	6	15		V	I_R = 100 μA
Thermal Resistance LED Junction-to-Pin		$R\theta_{J-PIN}$		150		°C/W/ LED Chip	

Notes:

4. These devices are categorized for luminous intensity with the intensity category designated by a letter code on the side of the package.
5. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and is that single wavelength which defines the color of the device. Yellow and green devices are categorized for dominant wavelength with the color bin designated by a number code on the side of the package.

Electrical

The HLMP-2300/-2400/-2500/-2600/-2700/-2800/ series of light bar devices are composed of two, four or eight light emitting diodes, with the light from each LED optically scattered to form an evenly illuminated light emitting surface. The LED's have a P-N junction diffused into the epitaxial layer on a GaP transparent substate.

The anode and cathode of each LED is brought out by separate pins. This universal pinout arrangement allows for the wiring of the LED's within a device in any of three possible configurations: parallel, series, or series/parallel.

The typical forward voltage values, scaled from Figure 5, should be used for calculating the current limiting resistor values and typical power dissipation. Expected maximum V_F values for the purpose of driver circuit design and maximum power dissipation may be calculated using the following V_F models:

$$V_F = 1.8V + I_{PEAK}\ (40\Omega)$$
$$\text{For } I_{PEAK} \geq 20mA$$

$$V_F = 1.6V + I_{DC}\ (50\Omega)$$
$$\text{For } 5mA \leq I_{DC} \leq 20mA$$

The maximum power dissipation can be calculated for any pulsed or DC drive condition. For DC operation, the maximum power dissipation is the product of the maximum forward voltage and the maximum forward current. For pulsed operation, the maximum power dissipation is the product of the maximum forward voltage at the peak forward current times the maximum average forward current. Maximum allowable power dissipation for any given ambient temperature and thermal resistance ($R\theta_{J-A}$) can be determined by using Figure 2. The solid line in Figure 2 ($R\theta_{J-A}$ of 538°C/W) represents a typical thermal resistance of a device socketed in a printed circuit board. The dashed lines represent achievable thermal resistances that can be obtained through improved thermal design. Once the maximum allowable power dissipation is determined, the maximum pulsed or DC forward current can be calculated.

Optical

The radiation pattern for these light bar devices is approximately Lambertian. The luminous sterance may be calculated using one of the two following formulas:

$$L_V\ (cd/m^2) = \frac{I_V\ (cd)}{A\ (m^2)}$$

$$L_V\ (\text{footlamberts}) = \frac{\pi I_V\ (cd)}{A\ (ft^2)}$$

Size of Light Emitting Area	Surface Area	
	Sq. Metres	Sq. Feet
8.89 mm x 8.89 mm	67.74×10^{-6}	729.16×10^{-6}
8.89 mm x 3.81 mm	33.87×10^{-6}	364.58×10^{-6}
8.89 mm x 19.05 mm	135.48×10^{-6}	1458.32×10^{-6}
3.81 mm x 19.05 mm	72.58×10^{-6}	781.25×10^{-6}

Refresh rates of 1 kHz or faster provide the most efficient operation resulting in the maximum possible time average luminous intensity.

The time average luminous intensity may be calculated using the relative efficiency characteristic of Figure 4, $\eta_{I_{PEAK}}$, and adjusted for operating ambient temperature. The time average luminous intensity at $T_A = 25°C$ is calculated as follows:

$$I_{V\ TIME\ AVG} = \left[\frac{I_{AVG}}{20mA}\right] (\eta_{I_{PEAK}})\ (I_V\ \text{Data Sheet})$$

Example: For HLMP-2735 series

$$\eta_{I_{PEAK}} = 1.18 \text{ at } I_{PEAK} = 48\ mA$$

$$I_{V\ TIME\ AVG} = \left[\frac{12mA}{20mA}\right]\ (1.18)\ (35\ mcd) = 25\ mcd$$

The time average luminous intensity may be adjusted for operating ambient temperature by the following exponential equation:

$$I_V\ (T_A) = I_V\ (25°C)\ e^{|K\ (T_A - 25°C)|}$$

Device	K
-2300/-2600 Series	-0.0131/°C
-2400/-2700 Series	-0.0112/°C
-2500/-2800 Series	-0.0104/°C

Example: $I_V\ (80°C) = (25\ mcd)e^{|-0.0112\ (80-25)|} = 14\ mcd$

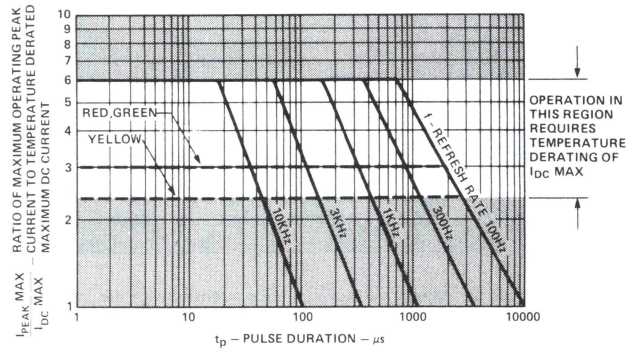


Figure 1. Maximum Allowed Peak Current vs. Pulse Duration.

Mechanical

These light bar devices may be operated in ambient temperatures above +60°C without derating when installed in a PC board configuration that provides a thermal resistance to ambient value less than 250° C/W/LED. See Figure 3 to determine the maximum allowed thermal resistance for the PC board, $R_{\theta PC-A}$, which will permit nonderated operation in a given ambient temperature.

To optimize device optical performance, specially developed plastics are used which restrict the solvents that may be used for cleaning. It is recommended that only mixtures of Freon (F113) and alcohol be used for vapor cleaning processes, with an immersion time in the vapors of less than two (2) minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolv DI-15 or DE-15, Arklone A or K. A 60°C (140°F) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and a thorough air dry. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, Ethanol, Isopropanol or water with a mild detergent.

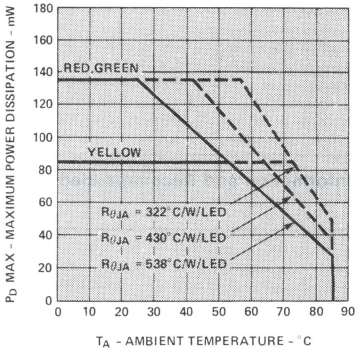


Figure 2. Maximum Allowable Power Dissipation per LED vs. Ambient Temperature Deratings Based on Maximum Allowable Thermal Resistance Values, LED Junction to Ambient on a per LED Basis, Tj MAX = 100° C.

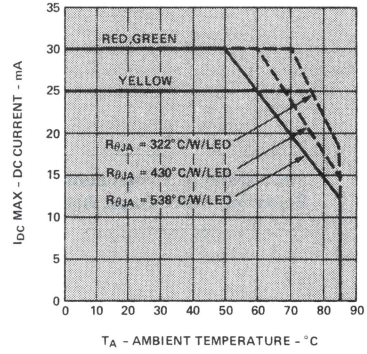


Figure 3. Maximum Allowable DC Current per LED vs. Ambient Temperature, Deratings Based on Maximum Allowable Thermal Resistance Values, LED Junction-to-Ambient on a per LED Basis, Tj MAX = 100° C.

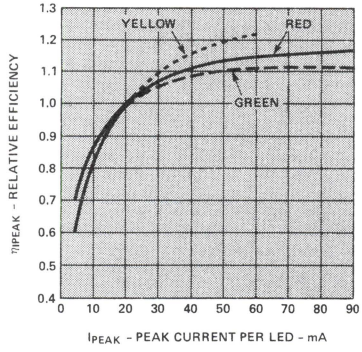


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current.

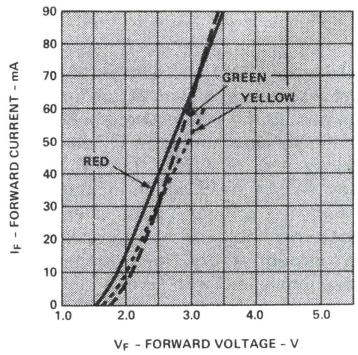


Figure 5. Forward Current vs. Forward Voltage Characteristics.

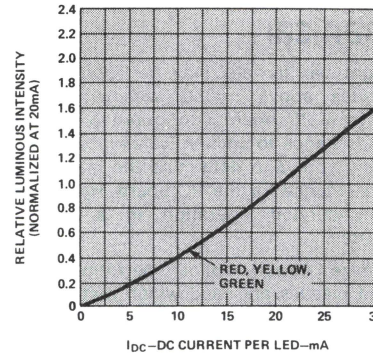


Figure 6. Relative Luminous Intensity vs. DC Forward Current.

For a Detailed Explanation on the Use of Data Sheet Information and Recommended Soldering Procedures, See Application Note 1005.

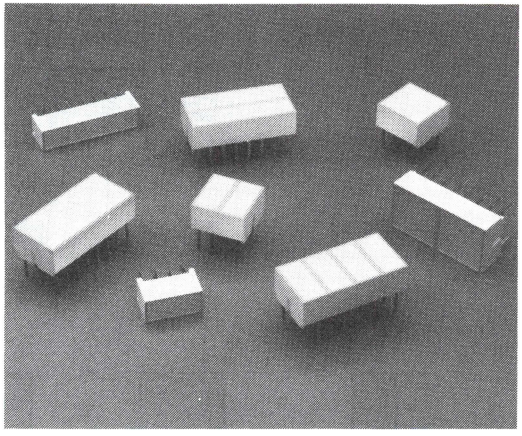
HEWLETT PACKARD

DOUBLE HETEROJUNCTION AlGaAs RED LOW CURRENT LIGHT BARS

2 CHIP SIP HLCP-A100
4 CHIP SIP HLCP-B100
4 CHIP DIP HLCP-C100/D100
8 CHIP DIP HLCP-E100/F100/G100/H100

Features

- **LOW POWER CONSUMPTION**
  3 mA Drive Current
  Low Forward Voltage
  Excellent for Battery Operated Applications
- **X-Y STACKABLE**
- **DEEP RED COLOR**



Description

The HLCP-X100 Series light bars utilize Hewlett-Packard's newly developed Double Heterojunction (DH) AlGaAs/GaAs material to emit deep red light at 645 nm. This material has outstanding efficiency at low drive currents and can be either DC or pulse driven. Typical applications include message annunciation for business machines, telecommunications, and instrumentation front panel, especially those requiring portability or battery backup.

Absolute Maximum Ratings

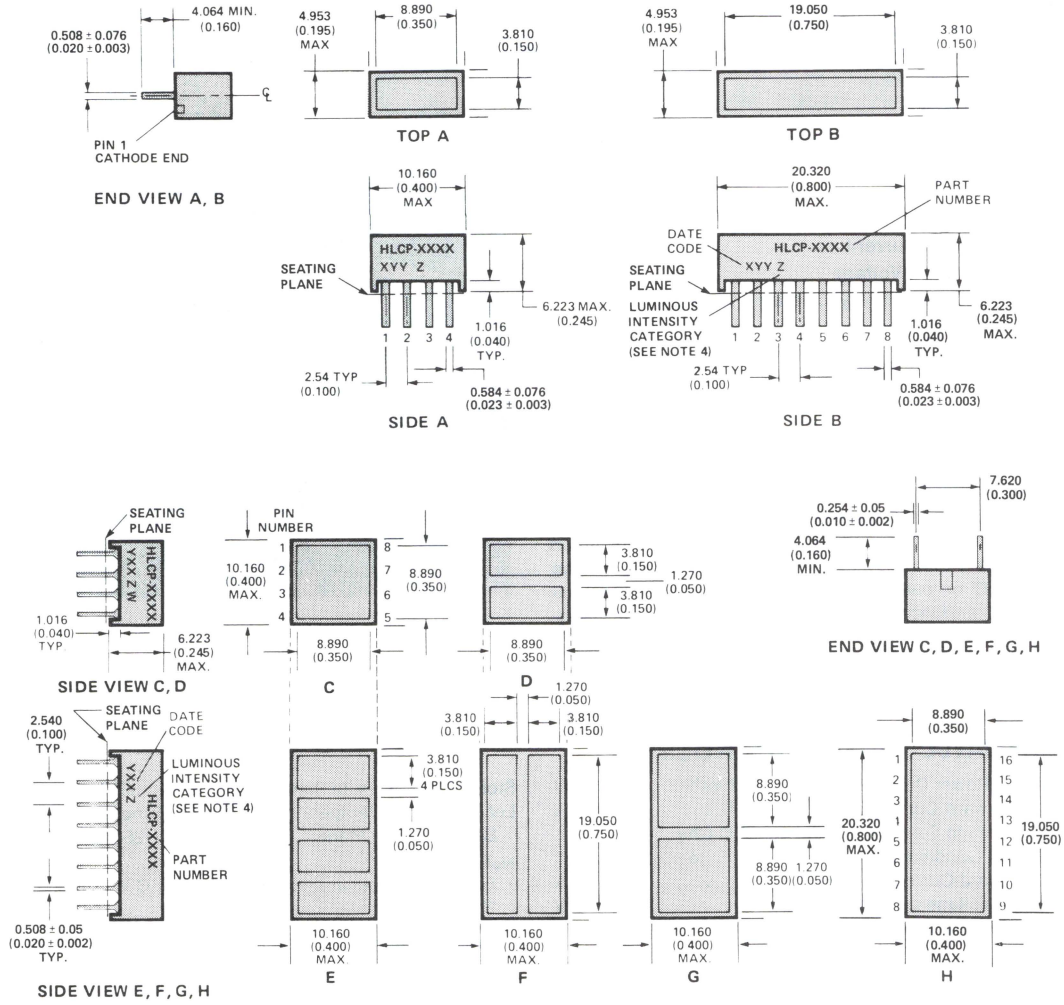
Average Power Dissipation per LED Chip[1] ..... 37 mW
Peak Forward Current per LED Chip[1] ..... 45 mA
Time Average Forward Current per LED Chip,
Pulsed Conditions[2] ..... 15 mA, T_A = 25°C
DC Forward Current per LED Chip[3] ..... 15 mA
Reverse Voltage per LED Chip ..... 5 V
Operating Temperature Range ..... -20°C to +100°C
Storage Temperature Range ..... -55°C to +100°C
Lead Soldering Temperature 1.6 mm (1/16 inch)
Below Seating Plane ..... 260°C for 3 sec.

Notes:
1. For pulsed operation, derate above T_A = 87°C at 1.7 mW/°C per LED.
2. See Figure 1 to establish pulsed operating conditions.
3. For DC operation, derate above T_A = 91°C at 0.8 mA/°C per LED.

Selection Guide

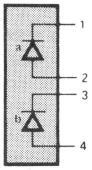
Light Bar Part Number HLCP- AlGaAs Red	Size of Light Emitting Areas	Number of Light Emitting Areas	Package Outline		Corresponding Panel and Legend Mount Part No. HLMP-
A100	8.89 mm x 3.81 mm (0.350 in. x 0.150 in.)	1	A		2599
B100	19.05 mm x 3.81 mm (0.750 in. x 0.150 in.)	1	B		2598
D100	8.89 mm x 3.81 mm (0.350 in. x 0.150 in.)	2	D		2698
E100	8.89 mm x 3.81 mm (0.350 in. x 0.150 in.)	4	E		2899
F100	8.89 mm x 19.05 mm (0.150 in. x 0.750 in.)	2	F		2899
C100	8.89 mm x 8.89 mm (0.350 in. x 0.350 in.)	1	C		2898
G100	8.89 mm x 8.89 mm (0.350 in. x 0.350 in.)	2	G		2899
H100	8.89 mm 19.05 mm (0.350 in. x 0.750 in.)	1	H		2899

Package Dimensions



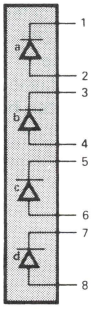
NOTE: DIMENSIONS IN MILLIMETRES (INCHES). TOLERANCES ±0.25 mm (±0.010 in) UNLESS OTHERWISE INDICATED.

Internal Circuit Diagrams

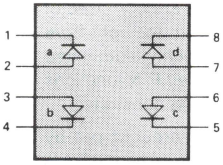


A

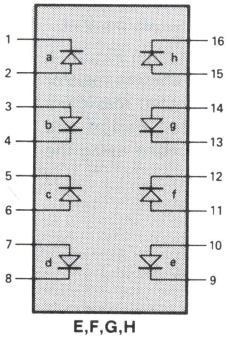
PIN FUNCTION		
PIN	A -2000/-2300/-2400 -2500	B -2100/-2350/-2450 -2550
1	Cathode — a	Cathode — a
2	Anode — a	Anode — a
3	Cathode — b	Cathode — b
4	Anode — b	Anode — b
5		Cathode — c
6		Anode — c
7		Cathode — d
8		Anode — d



B



C,D



E,F,G,H

PIN	PIN FUNCTION	
	C, D	E, F, G, H
1	CATHODE a	CATHODE a
2	ANODE a	ANODE a
3	ANODE b	ANODE b
4	CATHODE b	CATHODE b
5	CATHODE c	CATHODE c
6	ANODE c	ANODE c
7	ANODE d	ANODE d
8	CATHODE d	CATHODE d
9		CATHODE e
10		ANODE e
11		ANODE f
12		CATHODE f
13		CATHODE g
14		ANODE g
15		ANODE h
16		CATHODE h

Electrical/Optical Characteristics at $T_A = 25°C$

Parameter	HLCP	Symbol	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity[4] Per Light Emitting Area	A100	I_V	3.0	7.5		mcd	3 mA DC
				12.0		mcd	20 mA Pk: 1 of 4 DF
	B100	I_V	6.0	15		mcd	3 mA DC
				24.0		mcd	20 mA Pk: 1 of 4 DF
	C100	I_V	6.0	15		mcd	3 mA DC
				24.0		mcd	20 mA Pk: 1 of 4 DF
	D100	I_V	3.0	7.5		mcd	3 mA DC
				12.0		mcd	20 mA Pk: 1 of 4 DF
	E100	I_V	3.0	7.5		mcd	3 mA DC
				12.0		mcd	20 mA Pk: 1 of 4 DF
	F100	I_V	6.0	15		mcd	3 mA DC
				24.0		mcd	20 mA Pk: 1 of 4 DF
	G100	I_V	6.0	15		mcd	3 mA DC
				24.0		mcd	20 mA Pk: 1 of 4 DF
	H100	I_V	12.0	30		mcd	3 mA DC
				48.0		mcd	20 mA Pk: 1 of 4 DF
Peak Wavelength		λ_{peak}		645		nm	
Dominant Wavelength[5]		λ_d		637		nm	
Forward Voltage Per Led		V_F		1.6		V	I_F = 3 mA
				1.8	2.2		I_F = 20 mA Pk: 1 of 4 DF
Reverse Breakdown Voltage Per LED		V_{BR}	5			V	I_R = 100 μA
Thermal Resistance LED Junction-to-Pin		$R\theta_{J\text{-}PIN}$		250		°C/W/ LED Chip	

Notes:
4. These devices are categorized for luminous intensity with the intensity category designated by a letter code on the side of the package.
5. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and is that single wavelength which defines the color of the device.

Electrical

The HLCP-X100 series of light bar devices are compsed of two, four or eight light emitting diodes, with the light from each LED optically scattered to form an evenly illuminated light emitting surface. These diodes have their P-N junctions formed in AlGaAs epitaxial layers on a GaAs substrate.

The anode and cathode of each LED is brought out by separate pins. This universal pinout arrangement allows for the wiring of the LED's within a device in any of three possible configurations: parallel, series, or series/parallel.

The typical forward voltage values, scaled from Figure 4, should be used for calculating the current limiting resistor values and typical power dissipation. Expected maximum V_F values for the purpose of driver circuit design and maximum power dissipation may be calculated using the following V_F models:

$V_{F_{MAX}} = 2.0\ V + I_F\ (10\ \Omega),\ I_F \geq 20\ mA$

$V_{F_{MAX}} = 1.8\ V + I_F\ (20\ \Omega),\ I_F \leq 20\ mA$

The maximum power dissipation can be calculated for any pulsed or DC drive condition. For DC operation, the maximum power dissipation is the product of the maximum forward voltage and the maximum forward current. For pulsed operation, the maximum power dissipation is the product of the maximum forward voltage at the peak forward current times the maximum average forward current. Maximum allowable current for any given ambient temperature and thermal resistance ($R\theta_{J\text{-}A}$) can be determined by using Figure 2. The solid line in Figure 2 ($R\theta_{J\text{-}A}$ of 538° C/W) represents a typical thermal resistance of a device socketed in a printed circuit board. The dashed lines represent achievable thermal resistances that can be obtained through improved thermal design.

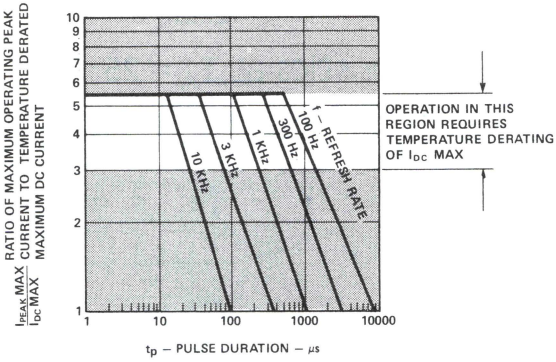


Figure 1. Maximum Allowable Peak Current vs. Pulse Duration

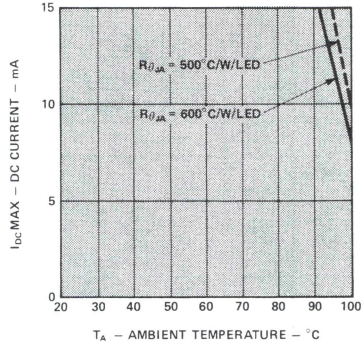


Figure 2. Maximum Allowed DC Current per LED vs. Ambient Temperature, Deratings Based on Maximum Allowable Thermal Resistance Values, LED Junction-to-Ambient on a per LED Basis, T_JMAX = 110° C

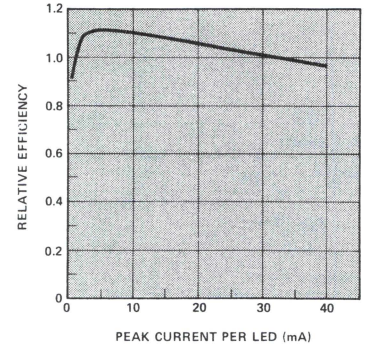


Figure 3. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

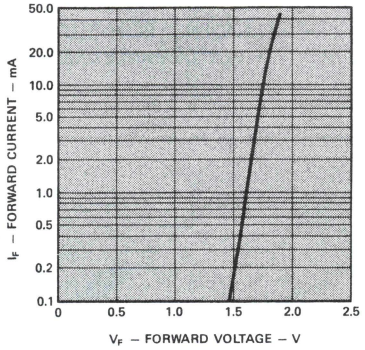


Figure 4. Forward Current vs. Forward Voltage Characteristics

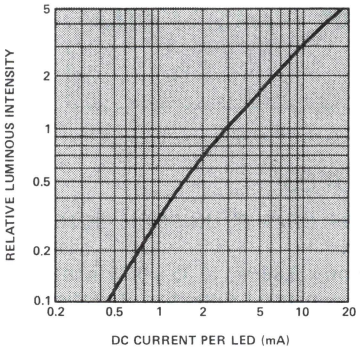


Figure 5. Relative Luminous Intensity vs. DC Forward Current

For a Detailed Explanation on the Use of Data Sheet Information and Recommended Soldering Procedures, See Application Notes 1005 and 1027.

HEWLETT PACKARD

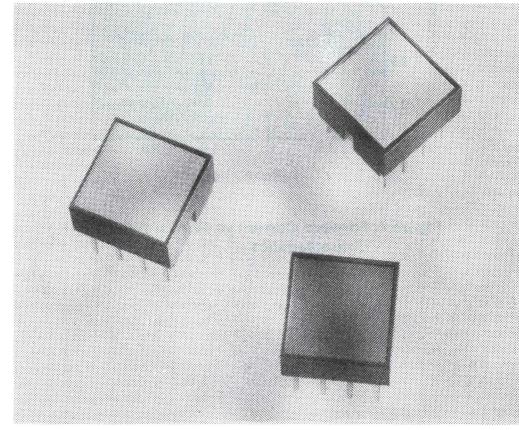
LED BICOLOR LIGHT BARS

DIP — Single Light Emitting Area

HIGH EFFICIENCY RED/YELLOW HLMP-2950
HIGH EFFICIENCY RED/HIGH PERFORMANCE GREEN HLMP-2965

Features

- LARGE, BRIGHT, UNIFORM LIGHT EMITTING AREA
  8.89mm x 8.89mm (0.35 x 0.35 inch)
  Approximately Lambertian Radiation Pattern
- CHOICE OF TWO BICOLOR COMBINATIONS
- CATEGORIZED FOR LIGHT OUTPUT
- YELLOW AND GREEN CATEGORIZED FOR DOMINANT WAVELENGTH
- EXCELLENT ON-OFF CONTRAST
- EASILY MOUNTED ON P.C. BOARDS OR INDUSTRY STANDARD DIP SOCKETS
- MECHANICALLY RUGGED
- X-Y STACKABLE
- FLUSH MOUNTABLE
- CAN BE USED WITH HLMP-2898 PANEL AND LEGEND MOUNT
- LIGHT EMITTING SURFACE SUITABLE FOR LEGEND ATTACHMENT PER APPLICATION NOTE 1012
- I.C. COMPATIBLE



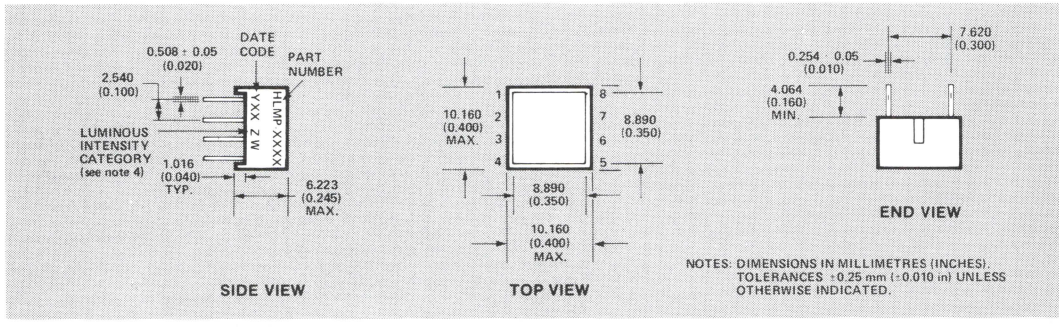
Applications

- TRISTATE LEGEND ILLUMINATION
- SPACE-CONSCIOUS FRONT PANEL STATUS INDICATORS
- BUSINESS MACHINE MESSAGE ANNUNCIATORS
- TELECOMMUNICATIONS INDICATORS
- TWO FUNCTION LIGHTED SWITCHES

Description

The HLMP-2950/-2965 light bars are bicolor light sources designed for a variety of applications where dual state or tristate illumination is required for the same annunciator function. In addition, both devices are capable of emitting a range of colors by pulse width modulation. These light bars are configured in dual-in-line packages which contain a single light emitting area. The high efficiency red (HER) and yellow LED chips utilize GaAsP on a transparent GaP substrate. The green LED chips utilize GaP on a transparent substrate.

Package Dimensions

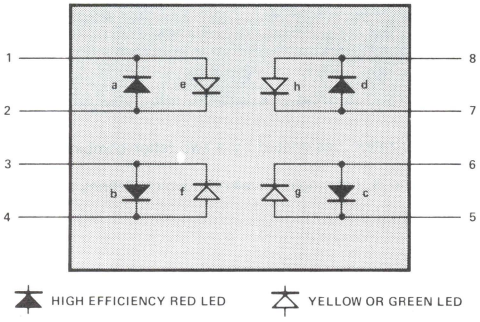


Absolute Maximum Ratings

Parameter	HLMP-2965	HLMP-2950
Average Power Dissipation per LED Chip[1]	135 mW	85 mW
Peak Forward Current per LED Chip, T_A = 50° C (Maximum Pulse Width = 2 ms)[1,2]	90 mA	60 mA
Time Average Forward Current per LED Chip, Pulsed Conditions[2]	25 mA; T_A = 25° C	20 mA; T_A = 50° C
DC Forward Current per LED Chip, T_A = 50° C[3]	30 mA	25 mA
Operating Temperature Range	-20° C to +85° C	-40° C to +85° C
Storage Temperature Range	-40° C to +85° C	
Lead Soldering Temperature, 1.6 mm (1/16 inch) Below Seating Plane	260° C for 3 seconds	

Notes:
1. For HLMP-2965, derate above T_A = 25° C at 1.8 mW/° C per LED chip. For HLMP-2950, derate above T_A = 50° C at 1.8 mW/° C per LED chip. See Figure 2.
2. See Figure 1 to establish pulsed operating conditions.
3. For HLMP-2965, derate above T_A = 50° C at 0.50 mA/° C per LED chip. For HLMP-2950, derate above T_A = 60° C at 0.50 mA/° C per LED chip. See Figure 3.

Internal Circuit Diagram



PIN	PIN FUNCTION	
	HER	YELLOW/ GREEN
1	CATHODE a	ANODE e
2	ANODE a	CATHODE e
3	ANODE b	CATHODE f
4	CATHODE b	ANODE f
5	CATHODE c	ANODE g
6	ANODE c	CATHODE g
7	ANODE d	CATHODE h
8	CATHODE d	ANODE h

Electrical/Optical Characteristics at T_A = 25°C

HIGH EFFICIENCY RED/YELLOW HLMP-2950

Parameter		Symbol	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity [4]	HER	I_V	13	43		mcd	20 mA DC
				49		mcd	60 mA Pk: 1 of 3 Duty Factor
	Yellow	I_V	13	35		mcd	20 mA DC
				43		mcd	60 mA Pk: 1 of 3 Duty Factor
Peak Wavelength	HER	λ_{PEAK}		635		nm	
	Yellow			583			
Dominant Wavelength [5]	HER	λ_d		626		nm	
	Yellow			585			
Forward Voltage	HER	V_F		2.0	2.6	V	I_F = 20 mA
	Yellow			2.1	2.6		
Thermal Resistance LED Junction-to-Pin		θ_{JC}		150		°C/W/LED	

Electrical/Optical Characteristics at $T_A = 25°C$

HIGH EFFICIENCY RED/GREEN HLMP-2965

Parameter		Symbol	Min.	Typ.	Max.	Units	Test Conditions
Luminous Intensity [4]	HER	I_V	19	43		mcd	20 mA DC
				49		mcd	60 mA Pk: 1 of 3 Duty Factor
	Green	I_V	25	50		mcd	20 mA DC
				56		mcd	60 mA Pk: 1 of 3 Duty Factor
Peak Wavelength	HER	λ_{PEAK}		635		nm	
	Green			565			
Dominant Wavelength [5]	HER	λ_d		626		nm	
	Green			572			
Forward Voltage	HER	V_F		2.0	2.6	V	$I_F = 20$ mA
	Green			2.2	2.6		
Thermal Resistance LED Junction-to-Pin		$R\theta_{J-PIN}$		150		°C/W/LED	

Notes:

4. These devices are categorized for luminous intensity with the intensity categorization designated by a two letter combination code located on the side of the package (Z = HER, W = Yellow or Green)
5. The dominant wavelength, λ_d, is derived from the C.I.E. chromaticity diagram and is that single wavelength which defines the color of the device.

Electrical

The HLMP-2950/-2965 bicolor light bar devices are composed of eight light emitting diodes: four High Efficiency Red and four that are either Yellow or Green. The light from each LED is optically scattered to form an evenly illuminated light emitting surface. The LED's are die attached and wire bonded in bicolor pairs, with the anode/cathode of each LED pair brought out by separate pins.

The typical forward voltage values, scaled from Figure 5, should be used for calculating the current limiting resistor values and typical power dissipation. Expected maximum V_F values for the purpose of driver circuit design and maximum power dissipation may be approximated using the following V_F models:

$$V_F = 1.8V + I_{PEAK}\,(40\Omega)$$
$$\text{For } I_{PEAK} \geq 20 \text{ mA}$$

$$V_F = 1.6V + I_{DC}\,(50\Omega)$$
$$\text{For } 5 \text{ mA} \leq I_{DC} \leq 20 \text{ mA}$$

The maximum power dissipation can be calculated for any pulsed or DC drive condition. For DC operation, the maximum power dissipation is the product of the maximum forward voltage and the maximum forward current. For pulsed operation, the maximum power dissipation is the product of the maximum forward voltage at the peak forward current times the maximum average forward current. Maximum allowable power dissipation for any given ambient temperature and thermal resistance ($R\theta_{J-A}$) can be determined by using Figure 2. The solid line in Figure 2 ($R\theta_{J-A}$ of 538° C/W) represents a typical thermal resistance of a device socketed in a printed circuit board. The dashed lines represent achievable thermal resistance that can be obtained through improved thermal design. Once the maximum allowable power dissipation is determined, the maximum pulsed or DC forward current can be calculated.

Optical

The radiation pattern for these light bar devices is approximately Lambertian. The luminous sterance may be calculated using one of the two following formulas:

$$L_v\,(\text{cd/m}^2) = \frac{I_v\,(\text{cd})}{A\,(\text{m}^2)} \qquad L_v\,(\text{footlamberts}) = \frac{\pi I_v\,(\text{cd})}{A\,(\text{ft}^2)}$$

where the area (A) of the light emitting surface is 67.74 x 10^{-6} m^2 (729.16 x 10^{-6} $ft.^2$).

For a Detailed Explanation on the Use of Data Sheet Information and Recommended Soldering Procedures, see Application Note 1005.

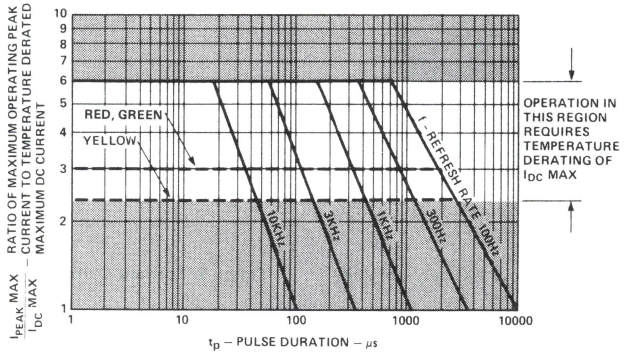


Figure 1. Maximum Allowed Peak Current vs. Pulse Duration.

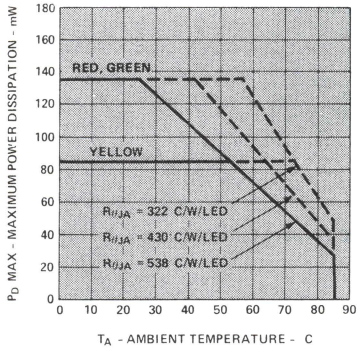


Figure 2. Maximum Allowable Power Dissipation per LED vs. Ambient Temperature. Deratings based on Maximum Allowable Thermal Resistance Values, LED Junction to Ambient on a per LED Basis, Tj MAX = 100° C.

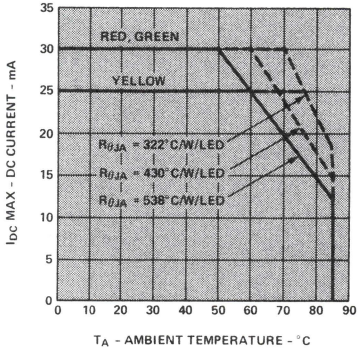


Figure 3. Maximum Allowable DC Current per LED vs. Ambient Temperature, Deratings Based on Maximum Allowable Thermal Resistance Values, LED Junction-to-Ambient on a per LED Basis, Tj MAX = 100° C.

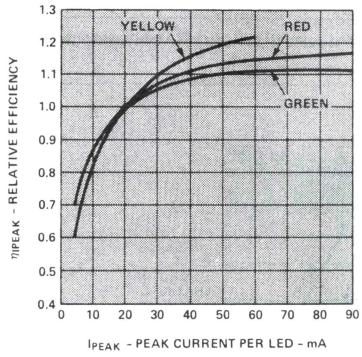


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current.

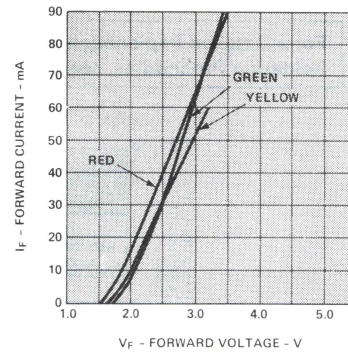


Figure 5. Forward Current vs. Forward Voltage Characteristics.

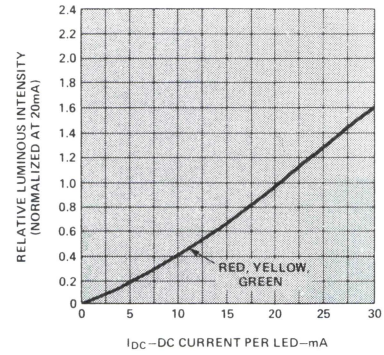


Figure 6. Relative Luminous Intensity vs. DC Forward Current.

Reversing Polarity LED Drivers

Bicolor LED light bar modules require a polarity reversing scheme to turn on the desired LED. Reversing line drivers, timers and memory drivers can be used to drive bicolor LED light bars.

The reversing line driver, which was originally designed to drive a data transmission line, can also be used as a polarity reversing driver for bicolor LED modules. The reversing line driver has a totem pole output structure that differs from most TTL circuits in that the output is designed to source as much current as it is capable of sinking.

Line drivers designed to operate from a single 5V supply are typically specified to source or sink 40 mA. Figure 7 shows the typical output characteristics of three different line drivers connected so that one output sources current across a load and the current is sunk by another output. This circuit is shown in Figure 8. At 40 mA output current, the output voltage typically varies from 2.4V (74128) to 2.9V (DM 8830, 9614) for $V_{CC} = 5.0V$. A basic bicolor LED circuit is shown in Figure 9. Since a line driver can supply 40 mA, it is capable of driving two LED pairs.

Some line drivers like the 9614 are constructed such that the sourcing output is brought out separately from the sinking output. With this type of line driver, the LED currents for each pair can be controlled separately. This technique is shown in Figure 10. Other line drivers provide a tri-state output control or provide other means for turning both LED's off. An example of this circuit technique is shown in Figure 11.

The NE556 dual timer, or two NE555 timers can also be used to drive bicolor light bars, as shown in Figure 12. The outputs at the NE555 timer are able to source or sink up to 200 mA. Connected as shown, each timer acts as an inverting buffer. This circuit has the advantage over the previous line driver circuits of being able to operate at a wide variety of power supply voltages ranging from 4.5 to 16 volts.

Memory drivers can also be used to drive bicolor light bars. Figure 13 shows a 75325 core memory driver being used to drive several pairs of bicolor LEDs. The 75325 is guaranteed to supply up to 600 mA of current with an output voltage considerably higher than 5V line drivers. The 75325 requires an additional 7.5V power supply at about 40 mA to properly bias the sourcing drivers. The 75325 allows tri-state (red, green, yellow, or emerald, off) operation.

By employing pulse width modulation techniques to any of these circuits a range of colors can be obtained. This technique is illustrated in Figure 14.

Hewlett-Packard cannot assume responsibility for use of any circuitry described other than the circuitry entirely embodied in an HP product.

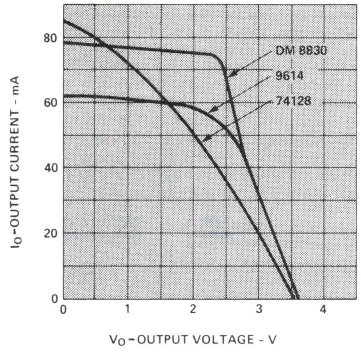


Figure 7. Typical Output Characteristics of Reversing Line Drivers.

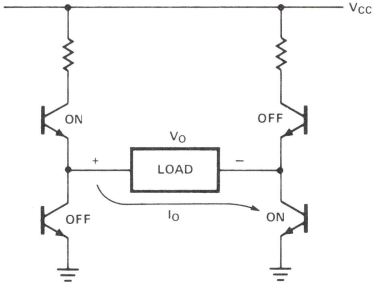


Figure 8. Line Driver Equivalent Circuit.

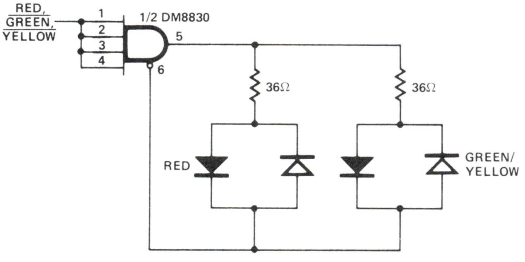


Figure 9. Typical Line Driver Circuit; Approximately 20mA/LED Pair.

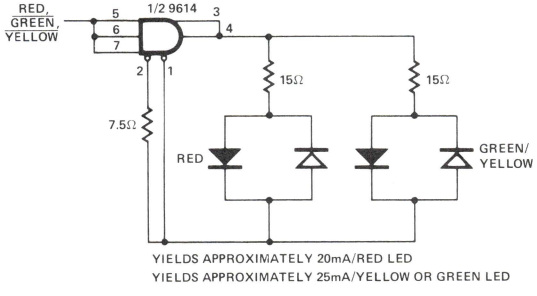


Figure 10. Techniques for Varying the Current of Each LED.

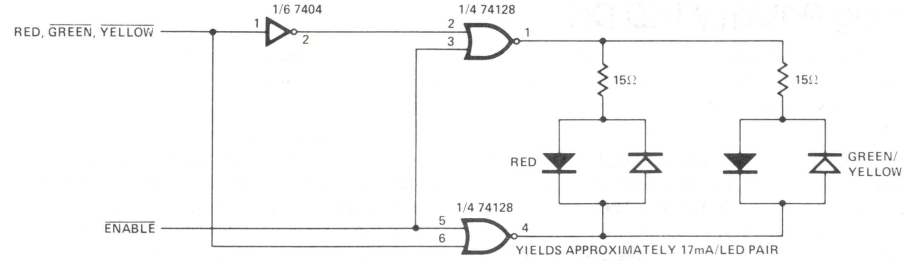


Figure 11. Tristate (Red, Green/Yellow, Off) Bicolor LED Driver.

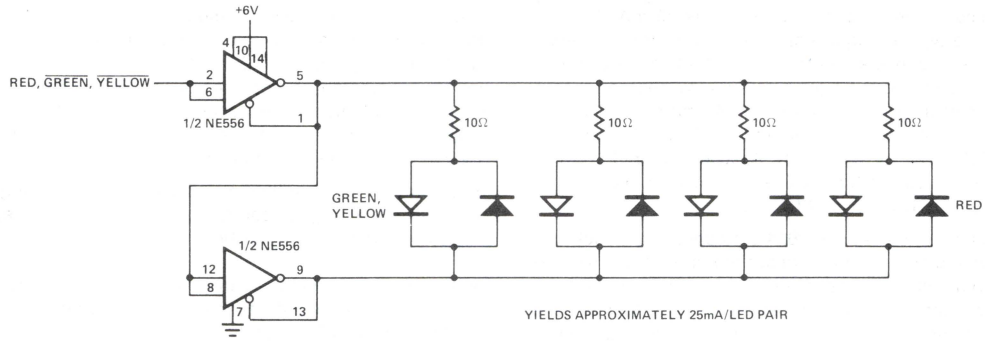


Figure 12. Use of Dual Timer to Drive Bicolor Light Bars

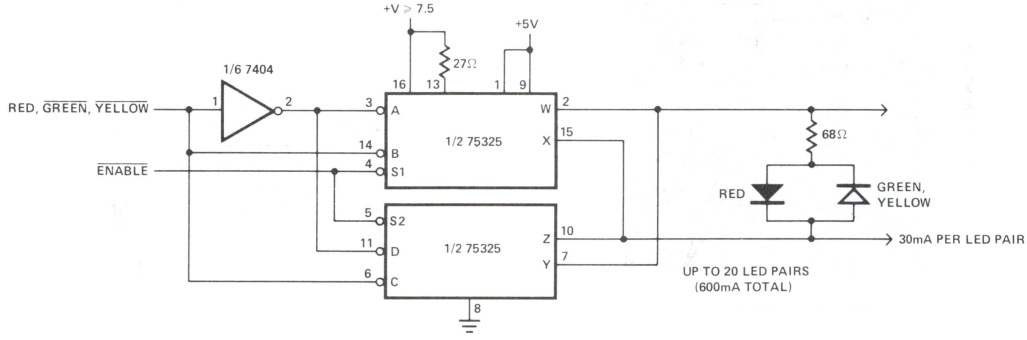


Figure 13. 75325 High Current Bicolor Driver

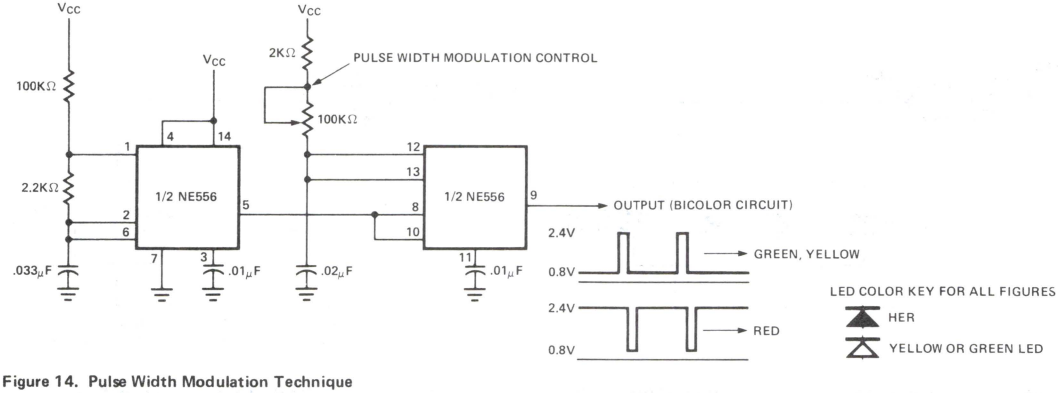


Figure 14. Pulse Width Modulation Technique

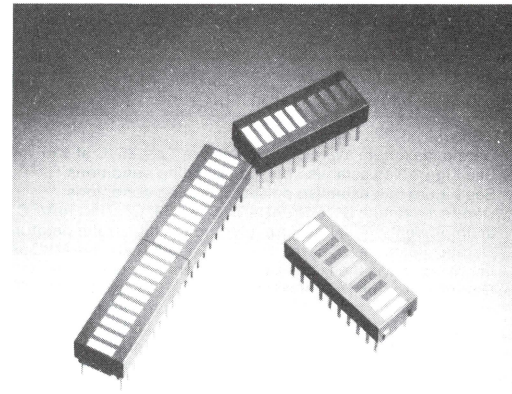
HEWLETT PACKARD

10-ELEMENT BAR GRAPH ARRAY

RED HDSP-4820
HIGH-EFFICIENCY RED HDSP-4830
YELLOW HDSP-4840
HIGH PERFORMANCE GREEN HDSP-4850
MULTICOLOR HDSP-4832
MULTICOLOR HDSP-4836

Features

- CUSTOM MULTICOLOR ARRAY CAPABILITY
- MATCHED LEDs FOR UNIFORM APPEARANCE
- END STACKABLE
- PACKAGE INTERLOCK ENSURES CORRECT ALIGNMENT
- LOW PROFILE PACKAGE
- RUGGED CONSTRUCTION— RELIABILITY DATA SHEETS AVAILABLE
- LARGE, EASILY RECOGNIZABLE SEGMENTS
- HIGH ON-OFF CONTRAST, SEGMENT TO SEGMENT
- WIDE VIEWING ANGLE
- CATEGORIZED FOR LUMINOUS INTENSITY
- HDSP-4832/-4836/-4840/-4850 CATEGORIZED FOR DOMINANT WAVELENGTH



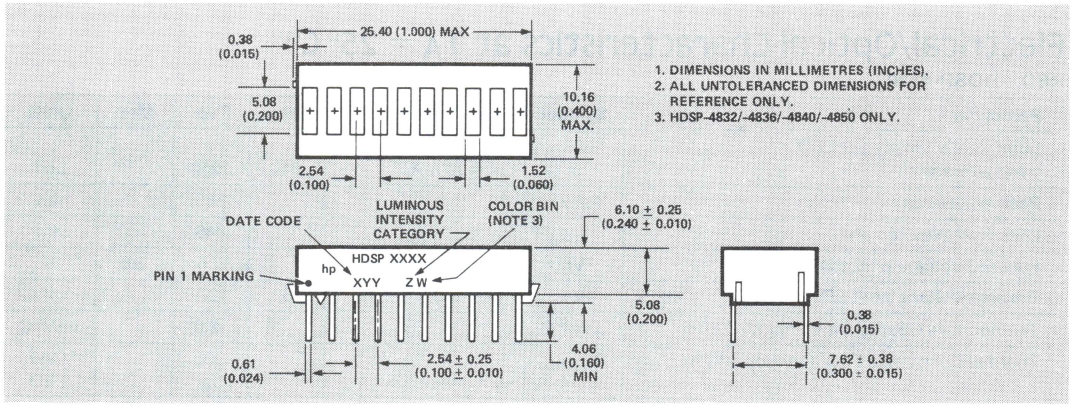
Applications

- INDUSTRIAL CONTROLS
- INSTRUMENTATION
- OFFICE EQUIPMENT
- COMPUTER PERIPHERALS
- CONSUMER PRODUCTS

Description

These 10-element LED arrays are designed to display information in easily recognizable bar graph form. The packages are end stackable and therefore capable of displaying long strings of information. Use of these bar graph arrays eliminates the alignment, intensity, and color matching problems associated with discrete LEDs. The HDSP-4820/-4830/-4840/-4850 each contain LEDs of just one color. The HDSP-4832/-4836 are multicolor arrays with High-Efficiency Red, Yellow, and Green LEDs in a single package. CUSTOM MULTICOLOR ARRAYS ARE AVAILABLE WITH MINIMUM DELIVERY REQUIREMENTS. CONTACT YOUR LOCAL DISTRIBUTOR OR HP SALES OFFICE FOR DETAILS.

Package Dimensions



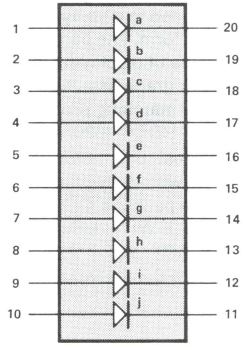
Absolute Maximum Ratings[9]

Parameter	HDSP-4820	HDSP-4830	HDSP-4840	HDSP-4850
Average Power Dissipation per LED ($T = 25°C$)[1]	125 mW	125 mW	125 mW	125 mW
Peak Forward Current per LED	150 mW[2]	90 mA[3]	60 mA[3]	90 mA[3]
DC Forward Current per LED	30 mA[4]	30 mA[5]	30 mA[6]	30 mA[7]
Operating Temperature Range	-40°C to +85°C			-20°C to +85°C
Storage Temperature Range	-40°C to +85°C			
Reverse Voltage per LED	3.0 V			
Lead Soldering Temperature (1.59 mm (1/16 inch) below seating plane	260°C for 3 seconds			

NOTES:

1. Derate maximum average power above $T_A = 25°C$ at 1.67 mW/°C. This derating assumes worst case $R\Theta_{J-A} = 600°C/W/LED$.
2. See Figure 1 to establish pulsed operating conditions.
3. See Figure 6 to establish pulsed operating conditions.
4. Derate maximum DC current above $T_A = 63°C$ at 0.81 mA/°C per LED. This derating assumes worst case $R\Theta_{J-A} = 600°C/W/LED$. With an improved thermal design, operation at higher temperatures without derating is possible. See Figure 2.
5. Derate maximum DC current above $T_A = 50°C$ at 0.6 mA/°C per LED. This derating assumes worst case $R\Theta_{J-A} = 600°C/W/LED$. With an improved thermal design, operation at higher temperatures without derating is possible. See Figure 7.
6. Derate maximum DC current above $T_A = 70°C$ at 0.67 mA/°C per LED. This derating assumes worst case $R\Theta_{J-A} = 600°C/W/LED$. With an improved thermal design, operation at higher temperatures without derating is possible. See Figure 8.
7. Derate maximum DC current above $T_A = 37°C$ at 0.48 mA/°C per LED. This derating assumes worst case $R\Theta_{J-A} = 600°C/W/LED$. With an improved thermal design, operation at higher temperatures without derating is possible. See Figure 9.
8. Clean only in water, Isopropanol, Ethanol, Freon TF or TE (or equivalent) and Genesolve DI-15 (or equivalent).
9. Absolute maximum ratings for the HER, Yellow, and Green elements of the multicolor arrays are identical to the HDSP-4830/-4840/-4850 maximum ratings.

Internal Circuit Diagram



PIN	FUNCTION	PIN	FUNCTION
1	ANODE-a	11	CATHODE-j
2	ANODE-b	12	CATHODE-i
3	ANODE-c	13	CATHODE-h
4	ANODE-d	14	CATHODE-g
5	ANODE-e	15	CATHODE-f
6	ANODE-f	16	CATHODE-e
7	ANODE-g	17	CATHODE-d
8	ANODE-h	18	CATHODE-c
9	ANODE-i	19	CATHODE-b
10	ANODE-j	20	CATHODE-a

Multicolor Array Segment Colors

Segment	HDSP-4832 Segment Color	HDSP-4836 Segment Color
a	HER	HER
b	HER	HER
c	HER	Yellow
d	Yellow	Yellow
e	Yellow	Green
f	Yellow	Green
g	Yellow	Yellow
h	Green	Yellow
i	Green	HER
j	Green	HER

Electrical/Optical Characteristics at $T_A = 25°C$[4]

RED HDSP-4820

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity per LED (Unit Average)[1]	I_F	$I_F = 20$ mA	610	1250		μcd
Peak Wavelength	λ_{PEAK}			655		nm
Dominant Wavelength[2]	λ_d			645		nm
Forward Voltage per LED	V_F	$I_F = 20$ mA		1.6	2.0	V
Reverse Voltage per LED	V_R	$I_R = 100$ μA	3	12[5]		V
Temperature Coefficient V_F per LED	ΔV_F/°C			-2.0		mV/°C
Thermal Resistance LED Junction-to-Pin	$R\Theta_{J-PIN}$			300		°C/W/LED

HIGH-EFFICIENCY RED HDSP-4830

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity per LED (Unit Average)[1]	I_V	I_F = 10 mA	900	3500		μcd
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength[2]	λ_d			626		nm
Forward Voltage per LED	V_F	I_F = 20 mA		2.1	2.5	V
Reverse Voltage per LED	V_R	I_R = 100 μA	3	30[5]		V
Temperature Coefficient V_F per LED	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin	$R_{\Theta J-PIN}$			300		°C/W/ LED

YELLOW HDSP-4840

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity per LED (Unit Average)[1]	I_V	I_F = 10 mA	600	1900		μcd
Peak Wavelength	λ_{PEAK}			583		nm
Dominant Wavelength[2,3]	λ_d		581	585	592	nm
Forward Voltage per LED	V_F	I_F = 20 mA		2.2	2.5	V
Reverse Voltage per LED	V_R	I_R = 100 μA	3	40[5]		V
Temperature Coefficient V_F per LED	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin	$R_{\Theta J-PIN}$			300		°C/W/ LED

GREEN HDSP-4850

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity per LED (Unit Average)[1]	I_V	I_F = 10 mA	600	1900		μcd
Peak Wavelength	λ_{PEAK}			566		nm
Dominant Wavelength[2,3]	λ_d			571	577	nm
Forward Voltage per LED	V_F	I_F = 10 mA		2.1	2.5	V
Reverse Voltage per LED	V_R	I_R = 100 μA	3	50[5]		V
Temperature Coefficient V_F per LED	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin	$R_{\Theta J-PIN}$			300		°C/W/ LED

NOTES:

1. The bar graph arrays are categorized for luminous intensity. The category is designated by a letter located on the side of the package.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and is that single wavelength which defines the color of the device.
3. The HDSP-4832/-4836/-4840/-4850 bar graph arrays are categorized by dominant wavelength with the category designated by a number adjacent to the intensity category letter. Only the yellow elements of the HDSP-4832/-4836 are categorized for color.
4. Electrical/optical characteristics of the High-Efficiency Red elements of the HDSP-4832/-4836 are identical to the HDSP-4830 characteristics. Characteristics of Yellow elements of the HDSP-4832/-4836 are identical to the HDSP-4840. Characteristics of Green elements of the HDSP-4832/-4836 are identical to the HDSP-4850.
5. Reverse voltage per LED should be limited to 3.0 V Max.

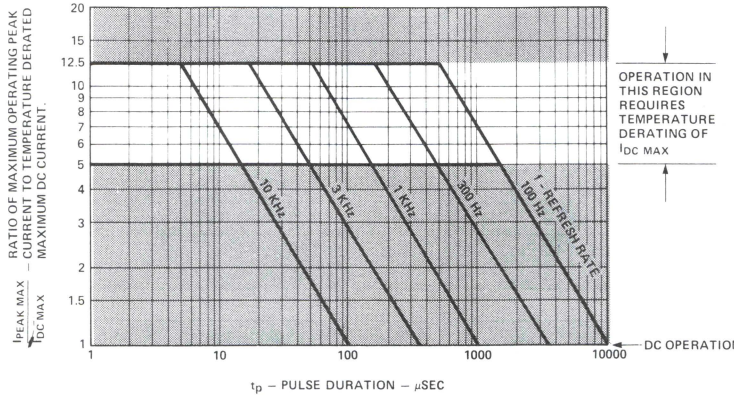


Figure 1. Maximum Tolerable Peak Current vs. Pulse Duration

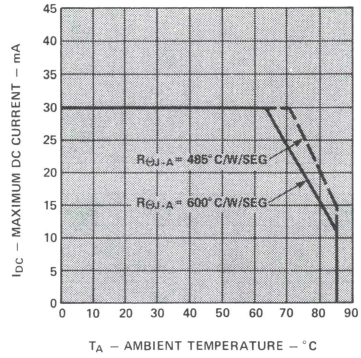


Figure 2. Maximum Allowable D.C. Current per LED vs. Ambient Temperature. Deratings based on Maximum Allowable Thermal Resistance, LED Junction-to-Ambient on a per LED basis. T_{JMAX} = 100° C

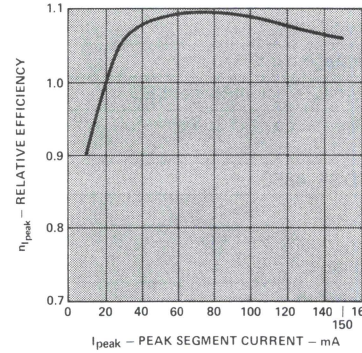


Figure 3. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

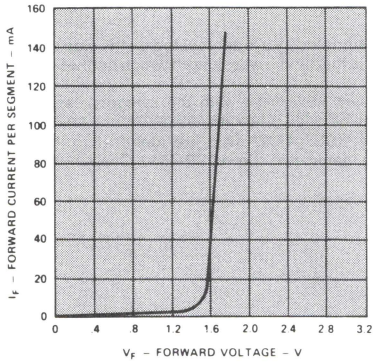


Figure 4. Forward Current vs. Forward Voltage

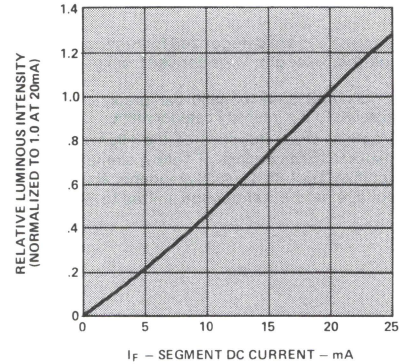


Figure 5. Relative Luminous Intensity vs. D.C. Forward Current

For a Detailed Explanation on the Use of Data Sheet Information and Recommended Soldering Procedures, See Application Note 1005.

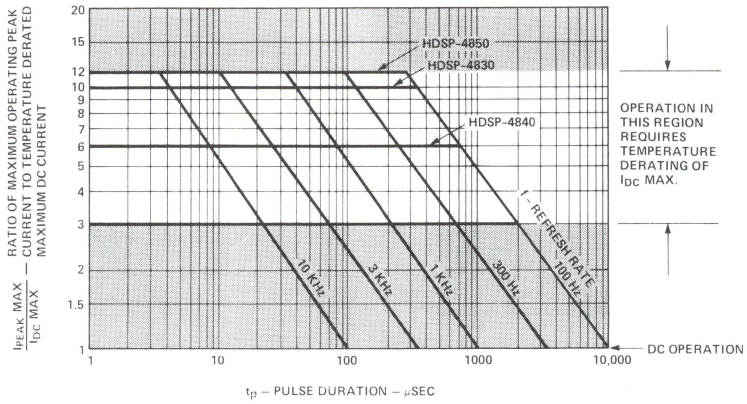


Figure 6. HDSP-4830/-4840/-4850 Maximum Tolerable Peak Current vs. Pulse Duration

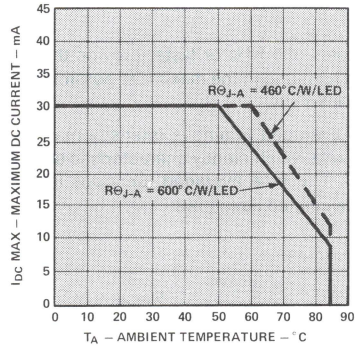


Figure 7. HDSP-4830 Maximum Allowable D.C. Current per LED vs. Ambient Temperature. Deratings Based on Maximum Allowable Thermal Resistance Values, LED Junction-to-Ambient on a per LED basis. $T_{J\ MAX}$ = 100° C.

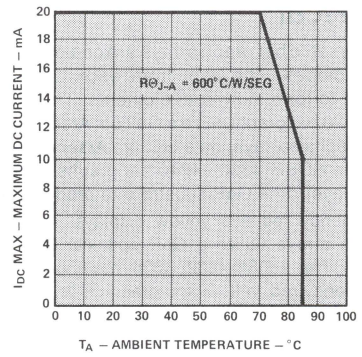


Figure 8. HDSP-4840 Maximum Allowable D.C. Current per LED vs. Ambient Temperature. Deratings Based on Maximum Allowable Thermal Resistance Values, LED Junction-to-Ambient on a per LED basis. $T_{J\ MAX}$ = 100° C.

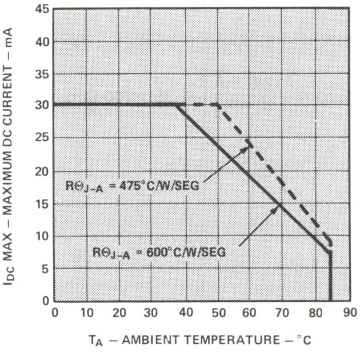


Figure 9. HDSP-4850 Maximum Allowable D.C. Current per LED vs. Ambient Temperature. Deratings Based on Maximum Allowable Thermal Resistance Values, LED Junction-to-Ambient on a per LED basis. $T_{J\text{-}MAX}$ = 100°C C.

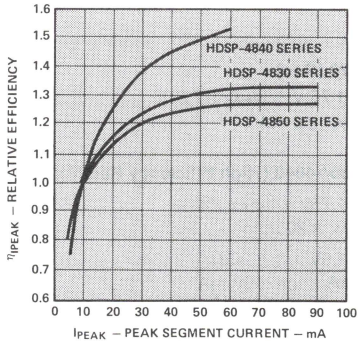


Figure 10. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

For a Detailed Explanation on the Use of Data Sheet Information and Recommended Soldering Procedures, See Application Note 1005.

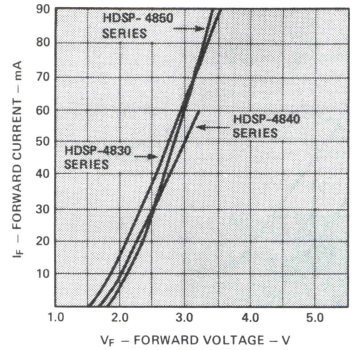


Figure 11. Forward Current vs. Forward Voltage

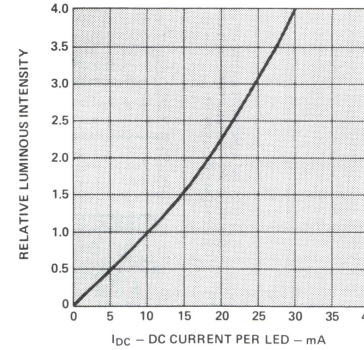


Figure 12. HDSP-4830/-4840/-4850 Relative Luminous Intensity vs. D.C. Forward Current

Electrical

These versatile bar graph arrays are composed of ten light emitting diodes. The light from each LED is optically stretched to form individual elements. The diodes in the HDSP-4820 bar graph utilize a Gallium Arsenide Phosphide (GaAsP) epitaxial layer on a Gallium Arsenide (GaAs) Substrate. The HDSP-4830/-4840 bar graphs utilize a GaAsP epitaxial layer on a GaP substrate to produce the brighter high-efficiency red and yellow displays. The HDSP-4850 bar graph arrays utilize a GaP epitaxial layer on a GaP substrate. The HDSP-4832/-4836 multicolor arrays have high efficiency red, yellow, and green LEDs in one package.

These display devices are designed to allow strobed operation. The typical forward voltage values, scaled from Figure 4 or 11, should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following $V_{F\,MAX}$ models.

HDSP-4820 (Red)

$V_{F\,MAX} = 1.75\ V + I_{PEAK}\,(12.5\Omega)$

For: $I_{PEAK} \geq 5$ mA

HDSP-4830/-4840 (High Efficiency Red/Yellow)

$V_{F\,MAX} = 1.75V + I_{PEAK}\,(38\Omega)$

For $I_{PEAK} \geq 20$ mA

$V_{F\,MAX} = 1.6V + I_{DC}\,(45\Omega)$

For: $5\text{ mA} \leq I_{DC} \leq 20$ mA

HDSP-4850 (Green)

$V_{F\,MAX} = 2.0V + I_{PEAK}\,(50\Omega)$

For: $I_{PEAK} > 5$ mA

Refresh rates of 1 KHz or faster provide the most efficient operation resulting in the maximum possible time averaged luminous intensity.

The time averaged luminous intensity may be calculated using the relative efficiency characteristic shown in Figures 3 and 10. The time averaged luminous intensity at $T_A = 25°C$ is calculated as follows:

$$I_{V\,TIME\,AVG} = \left[\frac{I_{F\,AVG}}{I_{F\,SPEC\,AVG}}\right](\eta I_{PEAK})\,(I_{V\,SPEC})$$

Example: For HDSP-4830 operating at $I_{PEAK} = 50$ mA, 1 of 4 Duty Factor

$$\eta I_{PEAK} = 1.35\ (\text{at } I_{PEAK} = 50\text{ mA})$$

$$I_{V\,TIME\,AVG} = \left[\frac{12.5\text{ mA}}{10\text{ mA}}\right](1.35)\,2280\ \mu\text{cd} = 3847\ \mu\text{cd}$$

For Further Information Concerning Bar Graph Arrays and Suggested Drive Circuits, Consult HP Application Note 1007 Entitled "Bar Graph Array Applications".

HEWLETT PACKARD

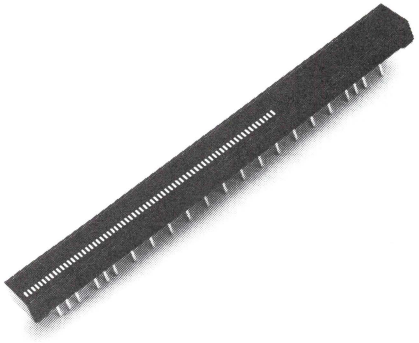
101 ELEMENT BAR GRAPH ARRAY

RED HDSP-8820
HIGH EFFICIENCY RED HDSP-8825
HIGH PERFORMANCE GREEN HDSP-8835

TECHNICAL DATA JANUARY 1986

Features

- **HIGH RESOLUTION (1%)**
- **EXCELLENT ELEMENT APPEARANCE**
  Wide, Recognizable Elements
  Matched LEDs for Uniformity
  Excellent Element Alignment
- **SINGLE-IN-LINE PACKAGE DESIGN**
  Sturdy Leads on Industry Standard 2.54 mm (0.100") Centers
  Environmentally Rugged Package
  Common Cathode Configuration
- **LOW POWER REQUIREMENTS**
  1.0 mA Average per Element at 1% Duty Cycle
- **SUPPORT ELECTRONICS**
  Easy Interface with Microprocessors



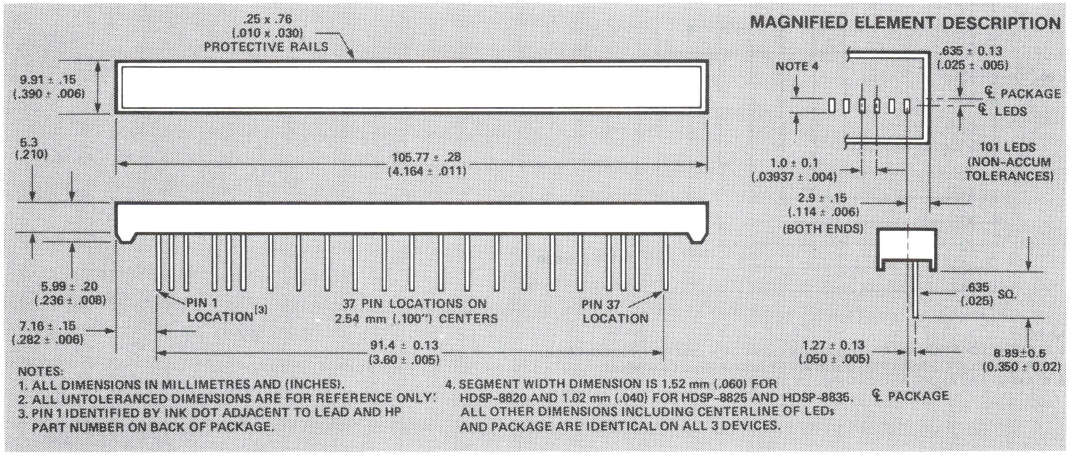
Description

The HDSP-88XX series is a family of 101-element LED linear arrays designed to display information in easily recognizable bar graph or position indicator form. The HDSP-8820, utilizing red GaAsP LED chips assembled on a PC board and enclosed in a red polycarbonate cover with an epoxy backfill seal, has 1.52 mm (0.060 inch) wide segments. The HDSP-8825 and HDSP-8835 are high efficiency red and high performance green respectively, each with a 1.02 mm (0.040 inch) segment width. The HDSP-8825 and HDSP-8835 have a clear polycarbonate lens. Mechanical considerations and pin-out are identical among all 3 devices. The common cathode chips are addressed via 22 single-in-line pins extending from the back side of the package.

Applications

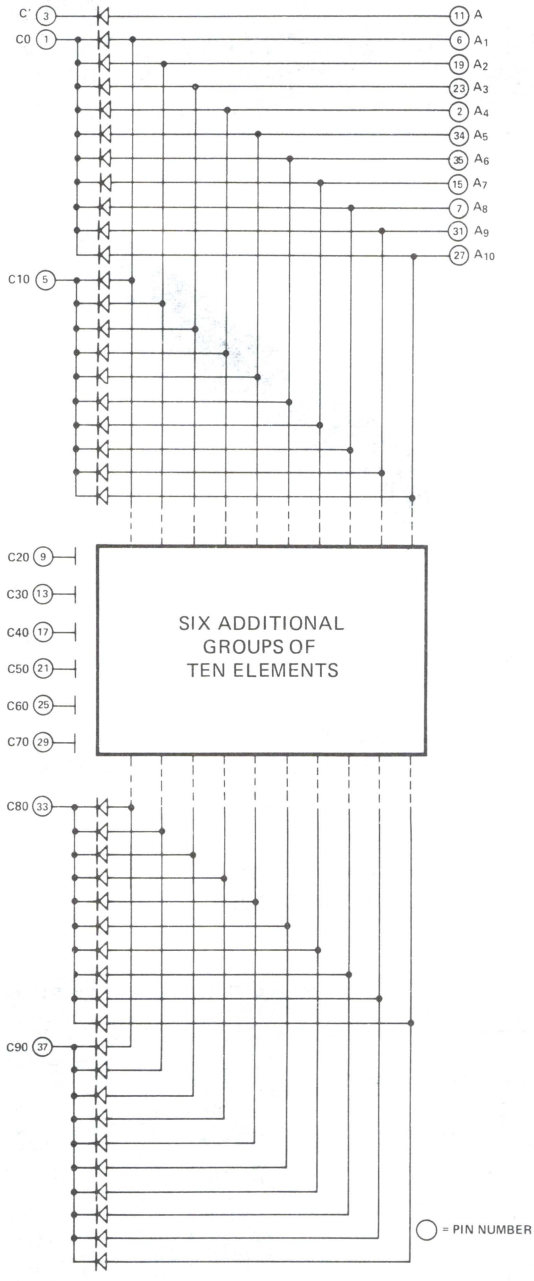
- **INDUSTRIAL PROCESS CONTROL SYSTEMS**
- **EDGEWISE PANEL METERS**
- **INSTRUMENTATION**
- **POSITION INDICATORS**
- **FLUID LEVEL INDICATORS**

Package Dimensions (1, 2)



NOTES:
1. ALL DIMENSIONS IN MILLIMETRES AND (INCHES).
2. ALL UNTOLERANCED DIMENSIONS ARE FOR REFERENCE ONLY.
3. PIN 1 IDENTIFIED BY INK DOT ADJACENT TO LEAD AND HP PART NUMBER ON BACK OF PACKAGE.
4. SEGMENT WIDTH DIMENSION IS 1.52 mm (.060) FOR HDSP-8820 AND 1.02 mm (.040) FOR HDSP-8825 AND HDSP-8835. ALL OTHER DIMENSIONS INCLUDING CENTERLINE OF LEDs AND PACKAGE ARE IDENTICAL ON ALL 3 DEVICES.

Internal Circuit Diagram [5, 6]



NOTES:
5. ELEMENT LOCATION NUMBER = COMMON CATHODE NUMBER + ANODE NUMBER. FOR EXAMPLE, ELEMENT 83 IS OBTAINES BY ADDRESSING C80 AND A3.
6. A' AND C' ARE ANODE AND CATHODE OF ELEMENT ZERO.

Device Pin Description

PIN LOCATION	FUNCTION
1	C0
2	A4
3	C'(6)
4	No Pin
5	C10
6	A1
7	A8
8	No Pin
9	C20
10	No Pin
11	A'(6)
12	No Pin
13	C30
14	No Pin
15	A7
16	No Pin
17	C40
18	No Pin
19	A2
20	No Pin
21	C50
22	No Pin
23	A3
24	No Pin
25	C60
26	No Pin
27	A10
28	No Pin
29	C70
30	No Pin
31	A9
32	No Pin
33	C80
34	A5
35	A6
36	No Pin
37	C90

Absolute Maximum Ratings

Parameter	HDSP-8820	HDSP-8825	HDSP-8835
Average Power per Element (T_A = 25° C)	15 mW	20 mW	20 mW
Peak Forward Current per Element (T_A = 25° C)[7] (Pulse Width ≤ 300 μs)	200 mA	150 mA	150 mA
Average Forward Current per Element (T_A = 25° C)[8]	7 mA	5 mA	5 mA
Operating Temperature Range	−40° to +85° C	−40° to +85° C	−40° to +85° C
Storage Temperature Range	−40° to +85° C	−40° to +85° C	−40° to +85° C
Reverse Voltage per Element or DP	5.0 V	5.0 V	5.0 V
Lead Solder Temperature 1.59 mm [1.16 inch] below seating plane[9]	260° C for 3 sec.	260° C for 3 sec.	260° C for 3 sec.

Notes:
7. See Figures 1 and 2 to establish pulsed operating conditions.
8. Derate maximum average forward current above T_A = 70° C at 0.16 mA/° C/Element for the HDSP-8820 and 0.11 mA/° C/Element for the HDSP-8825 and HDSP-8835. See Figures 3 and 4.
9. Clean only in water, Isopropanol, Ethanol, Freon TF or TE (or equivalent) and Genesolv DI-15 or DE-15 (or equivalent). See mechanical section of this data sheet for information on wave soldering conditions.

Electrical/Optical Characteristics at T_A = 25°C

RED HDSP-8820

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Time averaged Luminous Intensity per Element (Unit average) [10]	IV	100 mA Pk.: 1 of 110 Duty Factor	8	20		μcd
Peak Wavelength	λ_{PEAK}			655		nm
Dominant Wavelength [11]	λ_d			640		nm
Forward Voltage per Element	V_F	I_F = 100 mA		1.7	2.1	V
Reverse Voltage per Element	V_R	I_R = 100 μA	3.0			V
Temperature Coefficient V_F per Element	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin	$R\Theta_{J-PIN}$			700		°C/W/ LED

HIGH EFFICIENCY RED HDSP-8825

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Time averaged Luminous Intensity per Element (Unit average) [10]	IV	100 mA Pk.: 1 of 110 Duty Factor	60	175		μcd
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength [11]	λ_d			626		nm
Forward Voltage per Element	V_F	I_F = 100 mA		2.3	3.1	V
Reverse Voltage per Element	V_R	I_R = 100 μA	3.0			V
Temperature Coefficient V_F per Element	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin	$R\Theta_{J-PIN}$			1000		°C/W/ LED

Electrical/Optical Characteristics at $T_A = 25°C$ (continued)

HIGH PERFORMANCE GREEN HDSP-8835

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Time Averaged Luminous Intensity per Element (Unit average)[10]	IV	100 mA Pk.: 1 of 110 Duty Factor	70	175		μcd
Peak Wavelength	λ_{PEAK}			568		nm
Dominant Wavelength[11]	λ_d			574		nm
Forward Voltage per Element	V_F	$I_F = 100$ mA		2.3	3.1	V
Reverse Voltage per Element	V_R	$I_F = 100$ μA	3.0			V
Temperature Coefficient V_F per Element	$\Delta V_F/°C$			-2.0		mV/°C
Thermal Resistance LED Junction-to-Pin	$R\Theta_{J-PIN}$			1000		°C/W/ LED

Notes:
10. Operation at peak currents of less than 100 mA may cause intensity mismatch. Consult factory for low current operation.
11. The dominant wavelength, λd, is derived from the CIE chromaticity diagram and is the single wavelength which defines the color of the device.

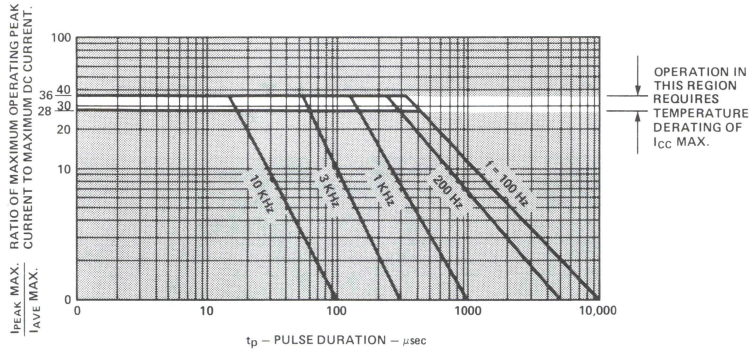


Figure 1. Maximum Tolerable Peak Current vs. Pulse Duration HDSP-8820

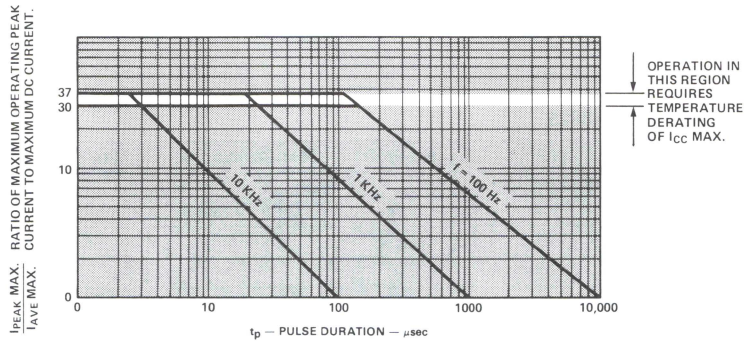


Figure 2. Maximum Tolerable Peak Current vs. Pulse Duration HDSP-8825 and HDSP-8835

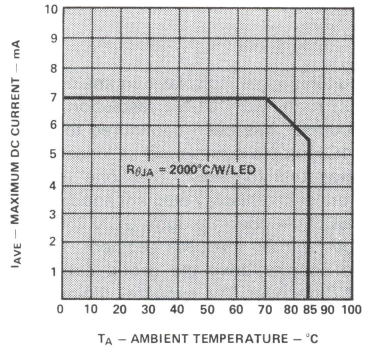


Figure 3. Maximum Allowable D.C. Current per LED vs. Ambient Temperature. Deratings based on Maximum Allowable Thermal Resistance, LED Junction-to-Ambient on a per LED basis. T_{JMAX} = 115° C HDSP-8820

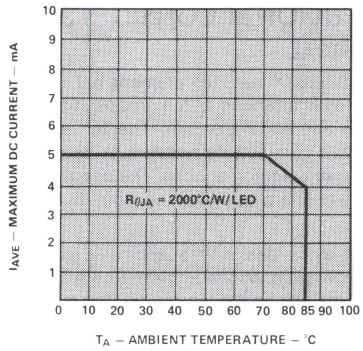


Figure 4. Maximum Allowable D.C. Current per LED vs. Ambient Temperature. Deratings based on Maximum Allowable Thermal Resistance, LED Junction-to-Ambient on a per LED basis. T_{JMAX} = 115° C HDSP-8825/HDSP-8835

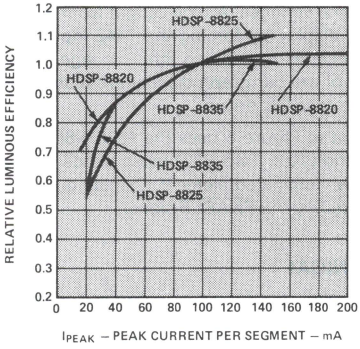


Figure 5. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

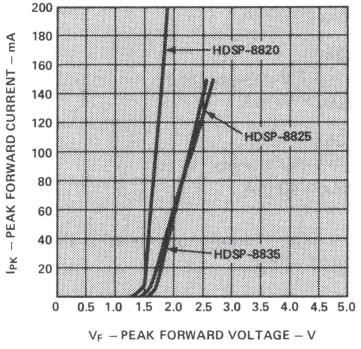


Figure 6. Forward Current vs. Forward Voltage

For A Detailed Explanation on the Use of Data Sheet Information, See Application Note 1005.

Operational Considerations

ELECTRICAL

The HDSP-88XX is a 101 element bar graph array. The linear array is arranged as ten groups of ten LED elements plus one additional element. The ten elements of each group have common cathodes. Like elements in the ten groups have common anodes. The device is addressed via 22 single-in-line pins extending from the back side of the display.

This display is designed specifically for strobed (multiplexed) operation. Minimum peak forward current at which all elements will be illuminated is 15 mA. Display aesthetics are specified at 100 mA, 1/110 DF, peak forward current. The typical forward voltage values, scaled from Figure 6 should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F model:

HDSP-8820

$V_{FMAX} = 2.02\ V + I_{PEAK}\ (0.8\ \Omega)$
For $I_{PEAK} > 40$ mA

HDSP-8825

$V_{FMAX} = 1.7\ V + I_{PEAK}\ (14\ \Omega)$
For $I_{PEAK} > 40$ mA

HDSP-8835

$V_{FMAX} = 1.7\ V + I_{PEAK}\ (14\ \Omega)$
For $I_{PEAK} > 40$ mA

The time averaged luminous intensity at $T_A = 25°C$ may be calculated using:

$$I_V \text{ Time Avg.} = \left[\frac{I_{F-AVG}}{I_{F-SPEC-AVG}}\right] \cdot \eta I_{PEAK} \cdot I_{V-SPEC}$$

where η, relative efficiency, may be determined from Figure 5.

The circuit in Figure 7 displays an analog input voltage in bar graph form with 101 bit resolution. The 74390 dual decade counter has been configured to count from 0 to 99. The 1Q outputs correspond to "ones" and the 2Q outputs correspond to "tens". The "one" outputs from the counter drives the display element anodes through a 7442 1 of 10 BCD decoder. Sprague UDN 2585 drivers source the anodes with 80 mA peak/segment. The "ten" outputs from the counter drive the group cathodes through a 74145 BCD decoder. The circuit multiplexes segments 100 to 91 first, then segments 90 to 81, and so on with segments 10 to 1 last. During the time that the output from the T.I. TL507C A/D converter is low the corresponding display elements will be illuminated.

The TL507C is an economical A/D converter with 7 bit resolution. The single output is pulse-width-modulated to correspond to the analog input voltage magnitude. With $V_{CC} = 5$ V the analog input voltage range is 1.3 V to 3.9 V. The TL507C output is reset each time the 74390 resets. Duration of the high output pulse is shorter for larger analog input voltages. A high output from the TL507C disables the display by forcing the 7442 inputs to an invalid state. Hence, as the analog input voltage increases more elements of the bar graph display are illuminated. Display element zero is DC driven.

The circuit in Figure 8 uses the HDSP-88XX as a 100 bit position indicator. Two BCD input words define the position of the illuminated element. Display duty factor, 1/100, is controlled by the $\overline{\text{ENABLE}}$ signal.

MECHANICAL

Suitable conditions for wave soldering depend on the specific kind of equipment and procedure used. A cool down period after flow solder and before flux rinse is recommended. For more information, consult the local Hewlett-Packard Sales Office or Hewlett-Packard Optoelectronics, Palo Alto, California.

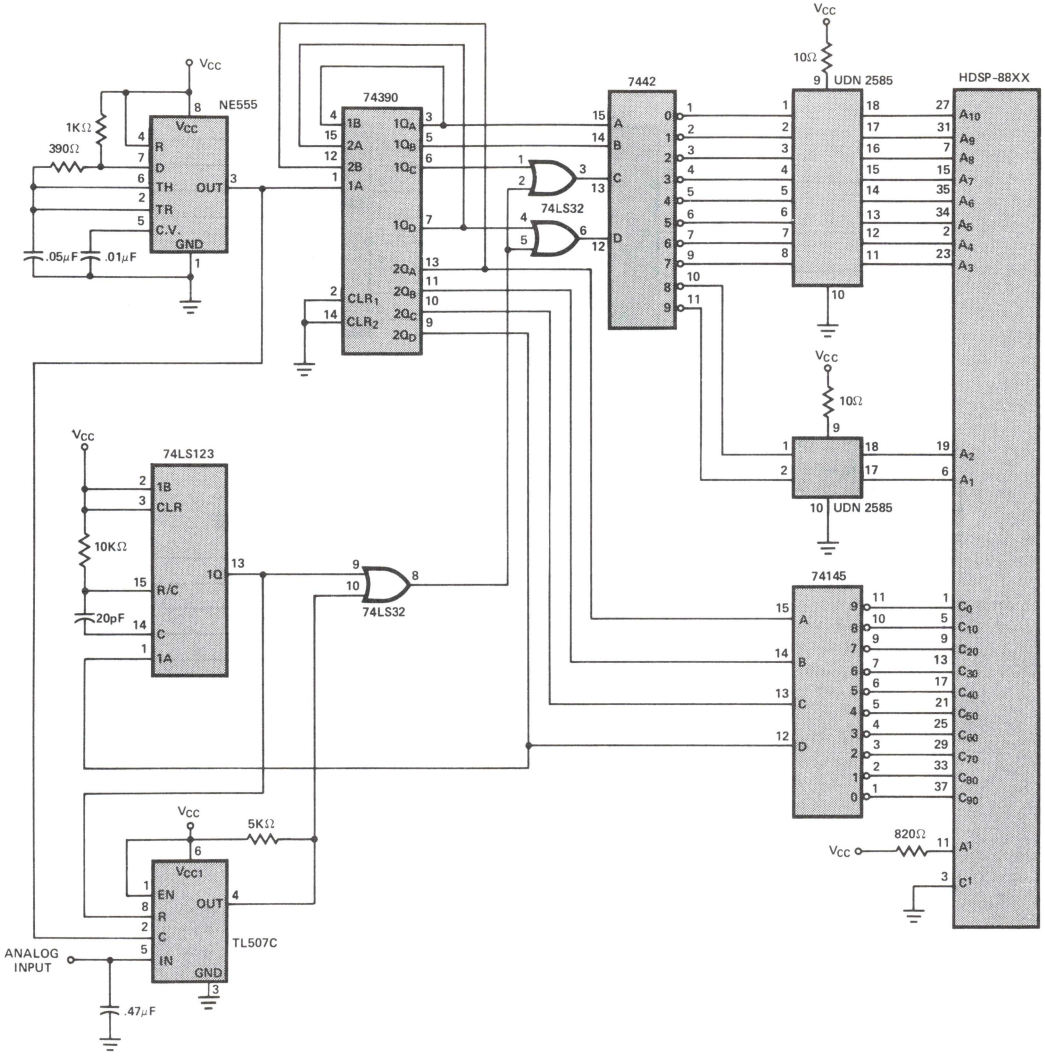


Figure 7. 101 Element Bar Graph

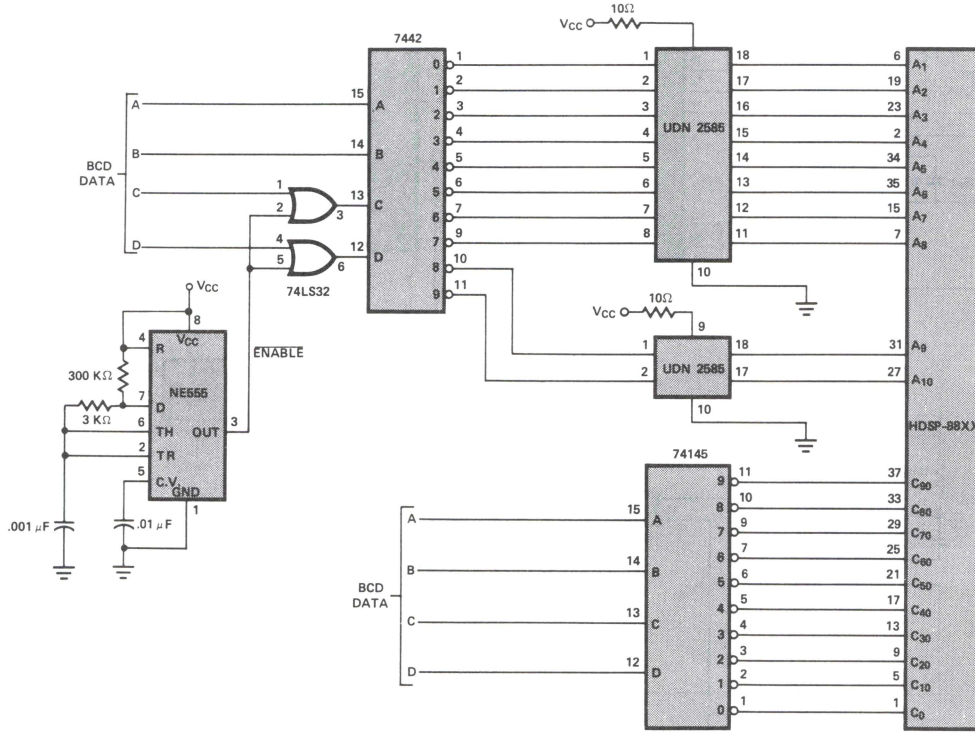


Figure 8. 100 Element Position Indicator

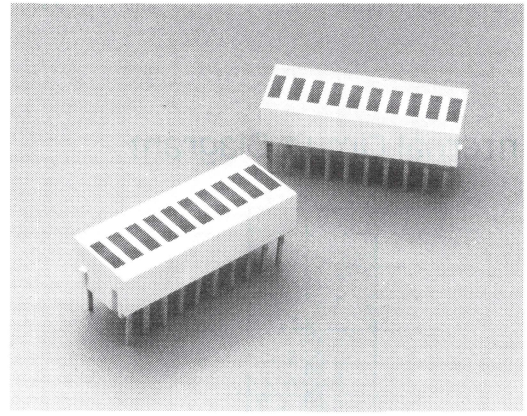
HEWLETT PACKARD

DOUBLE HETEROJUNCTION AlGaAs LOW CURRENT 10-ELEMENT BAR GRAPH ARRAY

AlGaAs RED HLCP-J100

Features

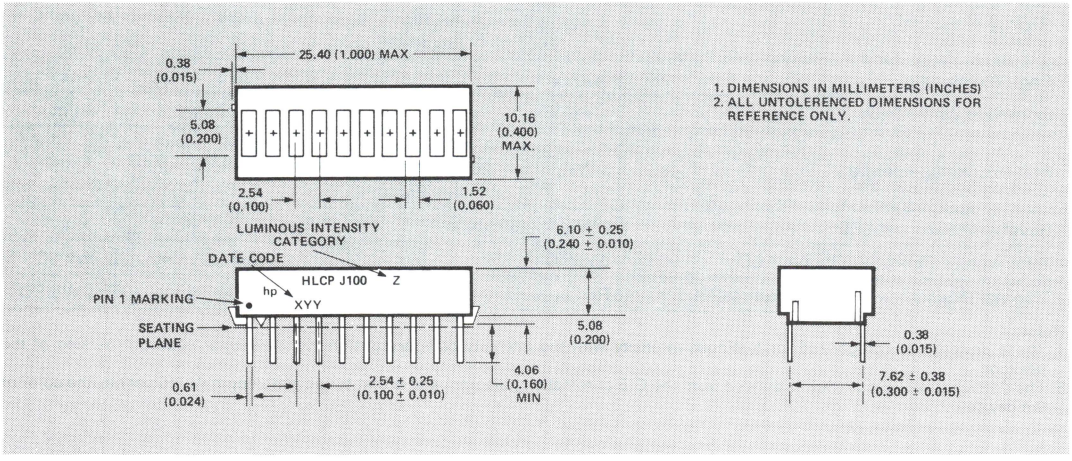
- **LOW POWER CONSUMPTION**
  Typical Intensity of 1.0 mcd @ 1 mA Drive Current
- **DEEP RED COLOR**
- **END-STACKABLE**
- **EXCELLENT ON-OFF CONTRAST**
- **WIDE VIEWING ANGLE**
- **MATCHED LEDs FOR UNIFORM APPEARANCE**



Description

The solid state 10-element LED bar graph array utilizes HP's newly developed double heterojunction (DH) AlGaAs/GaAs material technology. The material is characterized by outstanding light output efficiency over a wide range of drive currents. Use of these bar graph arrays eliminates the alignment, intensity and color matching problems associated with discrete LEDs. Typical applications are found in office equipment, instrumentation, industrial controls, and computer peripherals where portability or battery backup are important considerations.

Package Dimensions

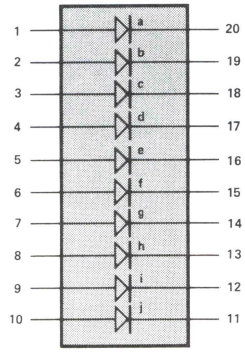


Absolute Maximum Ratings

Average Power Dissipation per LED
(T_A = 25° C)[1] ..... 37 mW
Peak Forward Current per LED ..... 45 mA
DC Forward Current per LED ..... 15 mA
Operating Temperature Range ..... -20° C to +100° C
Storage Temperature Range ..... -55° C to +100° C
Reverse Voltage per LED ..... 5 V
Lead Soldering Temperature (1.59 mm (1/16 inch)
below seating plane ..... 260° C for 3 sec.

Notes:
1. For pulsed operation, derate above T_A = 87° C at 1.7 mW/° C per LED.
2. See Figure 1 to establish pulsed operating conditions.
3. For DC operation, derate above T_A = 91° C at 0.8 mA/° C per LED.

Internal Circuit Diagram



PIN	FUNCTION	PIN	FUNCTION
1	ANODE-a	11	CATHODE-j
2	ANODE-b	12	CATHODE-i
3	ANODE-c	13	CATHODE-h
4	ANODE-d	14	CATHODE-g
5	ANODE-e	15	CATHODE-f
6	ANODE-f	16	CATHODE-e
7	ANODE-g	17	CATHODE-d
8	ANODE-h	18	CATHODE-c
9	ANODE-i	19	CATHODE-b
10	ANODE-j	20	CATHODE-a

Electrical/Optical Characteristics at T_A = 25°C

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity per LED (Unit Average)[1]	I_V	I_F = 1 mA DC	600	1000		μcd
		I_F = 20 mA Pk; 1 of 4 Duty Factor		5200		
Peak Wavelength	λ_{PEAK}			645		nm
Dominant Wavelength[2]	λ_d			637		nm
Forward Voltage per LED	V_F	I_F = 1 mA DC		1.6		V
		I_F = 20 mA Pk 1 of 4 Duty Factor		1.8	2.2	
Reverse Voltage per LED	V_R	I_R = 100 μA	5			V
Temperature Coefficient V_F per LED	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J\text{-}PIN}$			300		° C/W/LED

Notes:
4. These devices are categorized for luminous intensity with the intensity category designated by a letter code on the side of the package.
5. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and is that single wavelength which defines the color of the device.

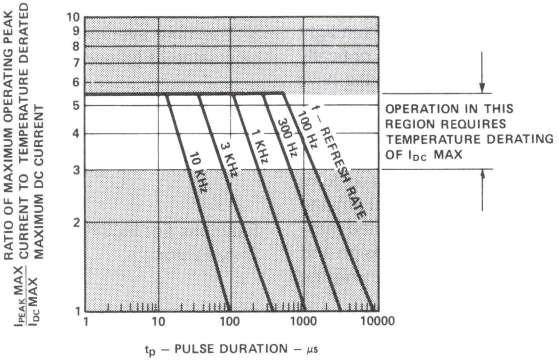


Figure 1. Maximum Allowed Peak Current vs. Pulse Duration

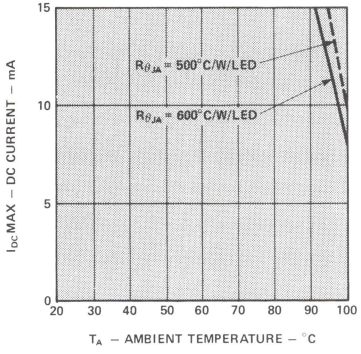


Figure 2. Maximum Allowed DC Current per LED vs. Ambient Temperature, Deratings Based on Maximum Allowable Thermal Resistance Values, LED Junction-to-Ambient on a per LED Basis, T_JMAX = 110°C

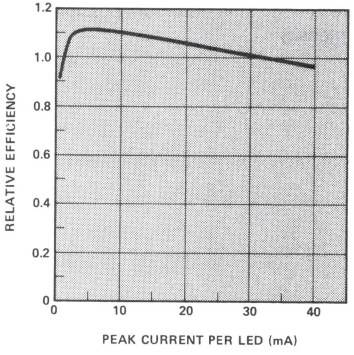


Figure 3. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

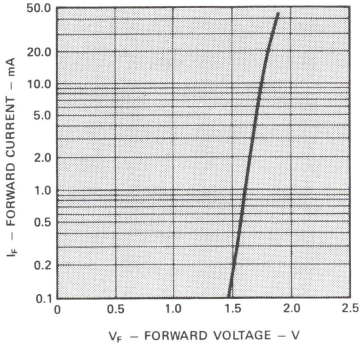


Figure 4. Forward Current vs. Forward Voltage

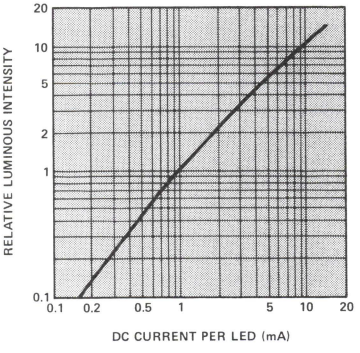


Figure 5. Relative Luminous Intensity vs. DC Forward Current

For a Detailed Explanation on the Use of Data Sheet Information and Recommended Soldering Procedures, See Application Note 1005.

Electrical

These versatile bar graph arrays are composed of ten light emitting diodes. The light from each LED is optically stretched to form individual elements. These diodes have their P-N junctions formed in AlGaAs epitaxial layers grown on a GaAs substrate.

These display devices are designated to allow strobed operation. The typical forward voltage values, scaled from Figure 4, should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following $V_{F\,MAX}$ models.

$$V_{F_{MAX}} = 1.8\ V + I_F\ (20\ \Omega),\ I_F \leq 20\ mA$$

$$V_{F_{MAX}} = 2.0\ V + I_F\ (10\ \Omega),\ I_F \geq 20\ mA$$

Refresh rates of 1 KHz or faster provide the most efficient operation resulting in the maximum possible time averaged luminous intensity.

The time averaged luminous intensity may be calculated using the relative efficiency characteristic shown in Figure 3. The time averaged luminous intensity at $T_A = 25°C$ is calculated as follows:

$$I_{V\ TIME\ AVG} = \left[\frac{I_{F\ AVG}}{I_{F\ SPEC\ AVG}}\right] (\eta I_{PEAK})\ (I_{V\ SPEC})$$

Example: For HLCP-J100 operating at $I_{PEAK} = 45$ mA, 1 of 3 Duty Factor

$$\eta I_{PEAK} = 0.94\ (\text{at } I_{PEAK} = 45\ mA)$$

$$I_{V\ TIME\ AVG} = \left[\frac{15\ mA}{1\ mA}\right] (94)\ 1000\ \mu cd = 1410\ \mu cd$$

For Further Information Concerning Bar Graph Arrays and Suggested Drive Circuits, consult HP Application Note 1007 Entitled "Bar Graph Array Applications".

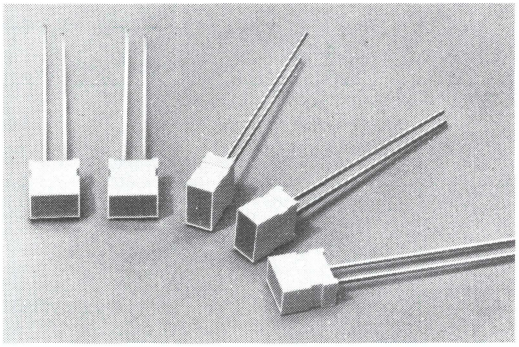
HEWLETT PACKARD

SINGLE CHIP LED LIGHT BAR

HIGH EFFICIENCY RED HLMP-T200 SERIES
YELLOW HLMP-T300 SERIES
ORANGE HLMP-T400 SERIES
HIGH PERFORMANCE GREEN HLMP-T500 SERIES

Features

- FLAT RECTANGULAR LIGHT EMITTING SURFACE
- CHOICE OF 4 BRIGHT COLORS
- EXCELLENT ON/OFF CONTRAST
- IDEAL AS FLUSH MOUNTED PANEL INDICATORS
- LONG LIFE: SOLID STATE RELIABILITY
- SOLDER COATED LEADS



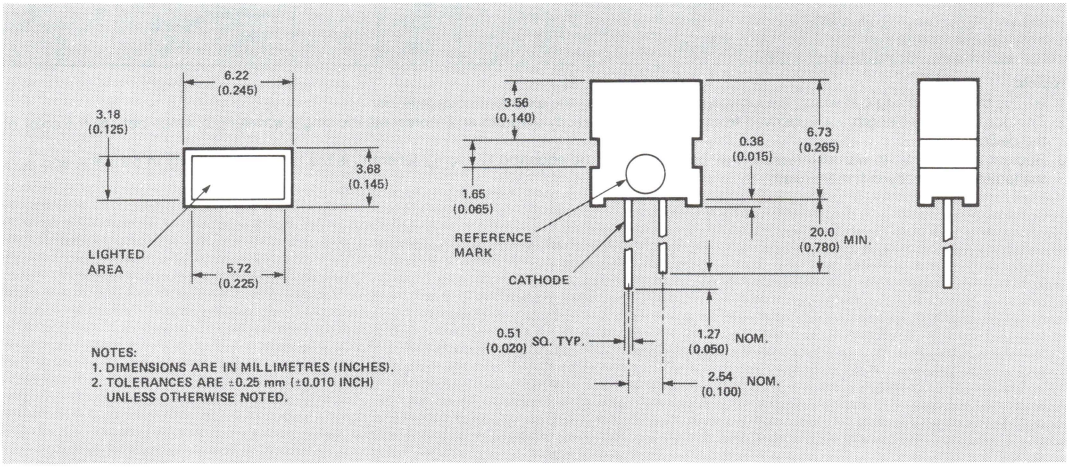
Description

The HLMP-T200/-T300/-T400/-T500 light bars are rectangular light sources designed for a variety of applications where this shape and a high sterance are desired. These light bars consist of a rectangular plastic case around an epoxy encapsulated LED lamp. The encapsulant is tinted to match the color of the emitted light. The flat top surface is exceptionally uniform in light emission and the plastic case eliminates light leakage from the sides of the device.

Applications

- BAR GRAPHS
- FRONT PANEL STATUS INDICATORS
- TELECOMMUNICATIONS INDICATORS
- PUSH BUTTON ILLUMINATION
- PC BOARD IDENTIFIERS
- BUSINESS MACHINE MESSAGE ANNUNCIATORS

Package Dimensions



NOTES:
1. DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. TOLERANCES ARE ±0.25 mm (±0.010 INCH) UNLESS OTHERWISE NOTED.

Electrical/Optical Characteristics at $T_A = 25°C$

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	High Efficiency Red T200	3.0	4.8		mcd	I_F = 20 mA
		Orange T400	3.0	4.8			
		Yellow T300	3.0	6.0			
		Green T500	3.0	6.0			
$2\Theta 1/2$	Included Angle Between Half Luminous Intensity Points	All		100		Deg.	I_F = 20 mA See Note 1
λ_{PEAK}	Peak Wavelength	High Efficiency Red		635		nm	Measurement at Peak
		Orange		612			
		Yellow		583			
		Green		565			
λ_d	Dominant Wavelength	High Efficiency Red		626		nm	See Note 2
		Orange		608			
		Yellow		585			
		Green		569			
τ_S	Speed of Response	High Efficiency Red		350		ns	
		Orange		350			
		Yellow		390			
		Green		870			
C	Capacitance	High Efficiency Red		4		pF	V_F = 0; f = 1 MHz
		Orange		4			
		Yellow		8			
		Green		11			
$R\theta_{JC}$	Thermal Resistance	All		120		°C/W	Junction to Cathode Lead at Seating Plane
V_F	Forward Voltage	HER/Orange	1.5	2.2	2.6	V	I_F = 20 mA
		Yellow	1.5	2.2	2.6		
		Green	1.6	2.3	2.6		
V_R	Reverse Breakdown Volt.	All	5.0			V	I_R = 100 μA
η_V	Luminous Efficacy	High Efficiency Red		145		$\frac{\text{lumens}}{\text{Watt}}$	See Note 3
		Orange		262			
		Yellow		500			
		Green		595			

Notes:

1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Characteristics at $T_A = 25°C$

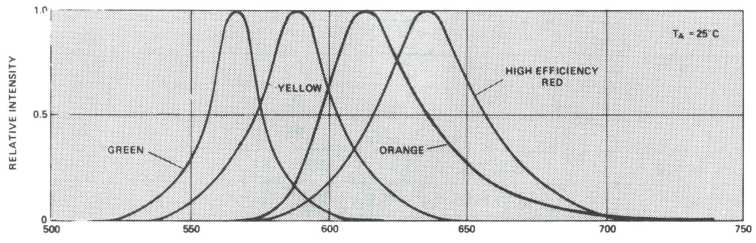


Figure 1. Relative Intensity vs. Wavelength.

High Efficiency Red, Orange, Yellow, and Green Light Bars

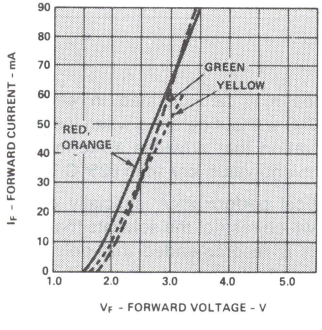


Figure 2. Forward Current vs. Forward Voltage Characteristics.

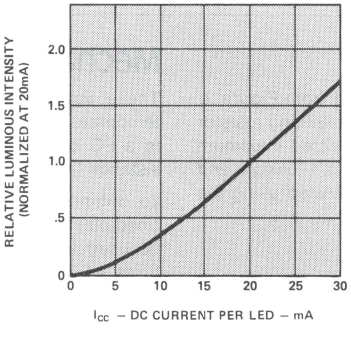


Figure 3. Relative Luminous Intensity vs. DC Forward Current.

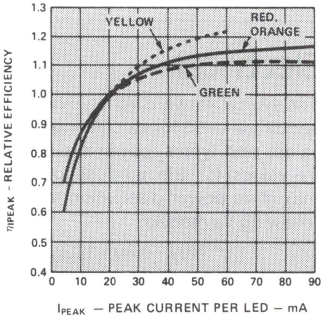


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. LED Peak Current.

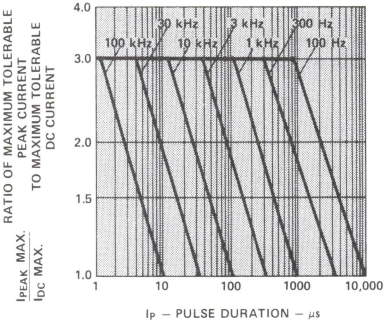


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings).

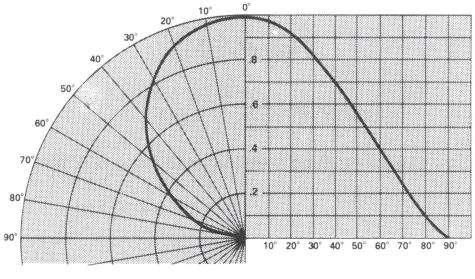


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	High Efficiency Red/ Orange	Yellow	Green	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Operating Temperature Range	-40 to +85	-40 to +85	-20 to +85	°C
Storage Temperature Range	-55 to +100	-55 to +100	-55 to +100	
Reverse Voltage (I_R = 100 μA)	5			V
Transient Forward Current[4] (10 μsec Pulse)	500			mA
Lead Soldering Temperature [1.6 mm (0.063 in.) below seating plane]	260° C for 3 seconds			

Notes:
1. See Figure 5 to establish pulsed operating conditions.
2. For Red, Orange, and Green derate linearly from 50° C at 0.5 mA/° C. For Yellow derate linearly from 50° C at 0.34 mA/° C.
3. For Red, Orange, and Green derate power linearly from 25° C at 1.6 mW/° C. For Yellow derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

Electrical

The typical forward voltage values, scaled from Figure 2, should be used for calculating the current limiting resistor values and typical power dissipation. Expected maximum V_F values for the purpose of driver circuit design and maximum power dissipation may be calculated using the following V_F models:

$$V_F = 1.8V + I_{PEAK}(40\Omega)$$
For $I_{PEAK} \geq 20$ mA

$$V_F = 1.6V + I_{DC}(50\Omega)$$
For $5\text{ mA} \leq I_{DC} \leq 20\text{ mA}$

Optical

The radiation pattern for these light bar devices is approximately Lambertian. The luminous sterance may be calculated using one of the two following formulas:

$$L_V\ (cd/m^2) = \frac{I_V\ (cd)}{A\ (m^2)}$$

$$L_V\ (\text{footlamberts}) = \frac{\pi I_V\ (cd)}{A\ (ft^2)}$$

Size of light emitting area (A)= 3.18 mm x 5.72 mm
$= 18.19 \times 10^{-6}\ m^2$
$= 195.8 \times 10^{-6}\ ft^2$

Mechanical

These light bar devices may be operated in ambient temperatures above +50° C without derating when installed in a PC board configuration that provides a thermal resistance (junction to ambient) value less than 625° C/W.

To optimize device optical performance, specially developed plastics are used which restrict the solvents that may be used for cleaning. It is recommended that only mixtures of Freon (F113) and alcohol be used for vapor cleaning processes, with an immersion time in the vapors of less than two (2) minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolv DI-15 or DE-15, Arklone A or K. A 60° C (140° F) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and a thorough air dry. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, Ethanol, Isopropanol or water with a mild detergent.

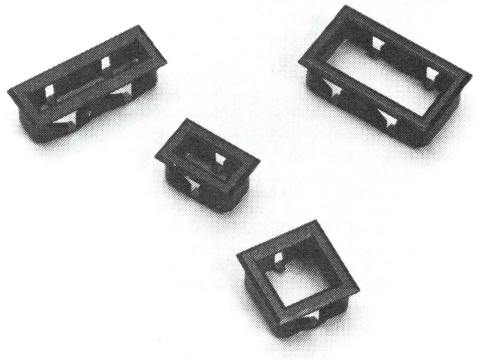
HEWLETT PACKARD

PANEL AND LEGEND MOUNTS FOR LED LIGHT BARS

HLMP-2598
HLMP-2599
HLMP-2898
HLMP-2899

Features

- **FIRMLY MOUNTS LIGHT BARS IN PANELS**
- **HOLDS LEGENDS FOR FRONT PANEL OR PC BOARD APPLICATIONS[1]**
- **ONE PIECE, SNAP-IN ASSEMBLY**
- **MATTE BLACK BEZEL DESIGN ENHANCES PANEL APPEARANCE**
- **FOUR SIZES AVAILABLE**
- **MAY BE INSTALLED IN A WIDE RANGE OF PANEL THICKNESSES**
- **PANEL HOLE EASILY PUNCHED OR MILLED**



Description

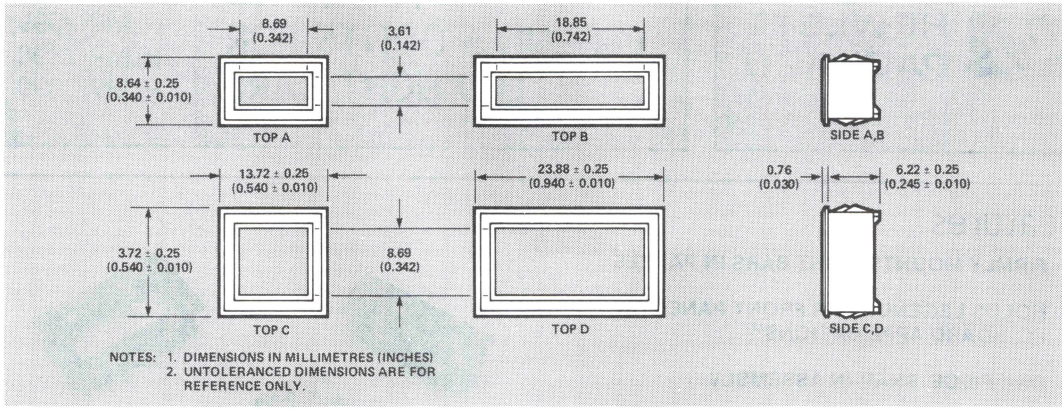
This series of black plastic bezel mounts is designed to install Hewlett-Packard Light Bars in instrument panels ranging in thickness from 1.52 mm (0.060 inch) to 3.18 mm (0.125 inch). A space has been provided for holding a 0.13 mm (0.005 inch) film legend over the light emitting surface of the light bar module.

Selection Guide

Panel and Legend Mount Part No. HLMP-	Corresponding Light Bar Module Part No. HLCP-	HLMP-	Panel Hole Installation Dimensions[2]	Package Outline	
2598	B100	2350, 2450, 2550	7.62 mm (0.300 inch) x 22.86 mm (0.900 inch)		B
2599	A100	2300, 2400, 2500	7.62 mm (0.300 inch) x 12.70 mm (0.500 inch)		A
2898	D100 C100	2600, 2700, 2800 2655, 2755, 2855 2950, 2965, 2980	12.70 mm (0.500 inch) x 12.70 mm (0.500 inch)		C
2899	E100 F100 G100 H100	2620, 2720, 2820 2635, 2735, 2835 2670, 2770, 2870 2685, 2785, 2885	12.70 mm (0.500 inch) x 22.86 mm (0.900 inch)		D

Notes:
1. Application Note 1012 addresses legend fabrication options.
2. Allowed hole tolerance: +0.00 mm, -0.13 mm (+0.000 inch, -0.005 inch). Permitted radius: 1.60 mm (0.063 inch).

Package Dimensions



Mounting Instructions

1. Mill[3] or punch a hole in the panel. Deburr, but do not chamfer, the edges of the hole.
2. Place the front of the mount against a solid, flat surface. A film legend with outside dimensions equal to the outside dimensions of the light bar may be placed in the mount or on the light bar light emitting surface. Press the light bar into the mount until the tabs snap over the back of the light bar[4]. When inserting the HLMP-2898, align the notched sides of the light bar with the mount sides which do not have the tabs). (See Figure 1)
3. Applying even pressure to the top of the mount, press the entire assembly into the hole from the front of the panel[5]. (See Figure 2)

NOTE: For thinner panels, the mount may be pressed into the panel first, then the light bar may be pressed into the mount from the back side of the panel.

Notes:
3. A 3.18 mm (0.125 inch) diameter mill may be used.
4. Repetitve insertion of the light bar into mount may cause damage to the mount.
5. Repetitive insertion of the mount into the panel will degrade the retention force of the mount.

Suggested Punch Sources

Hole punches may be ordered from one of the following sources:

Danly Machine Corporation
Punchrite Division
15400 Brookpark Road
Cleveland, OH 44135
(216) 267-1444

Ring Division
The Producto Machine Company
Jamestown, NY 14701
(800) 828-2216

Porter Precision Products Company
12522 Lakeland Road
Santa Fe Springs, CA 90670
(213) 946-1531

Di-Acro Division
Houdaille Industries
800 Jefferson Street
Lake City, MN 55041
(612) 345-4571

Installation Sketches

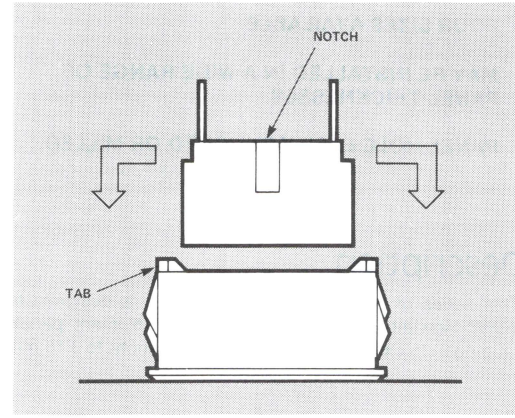


Figure 1. Installation of a Light Bar into a Panel Mount

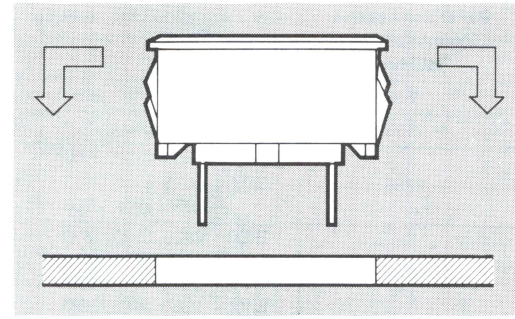


Figure 2. Installation of the Light Bar/Panel Mount Assembly into a Front Panel

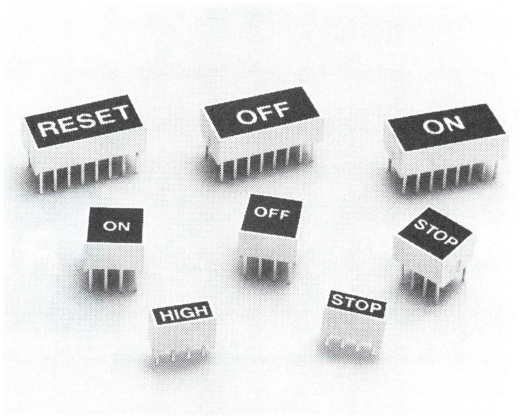
HEWLETT PACKARD

LIGHT BAR LEGENDS

STANDARD OPTIONS FOR:
HLCP-A100/HLMP-2300/-2400/-2500 SERIES
HLCP-C100/HLMP-2655/-2755/-2855 SERIES
HLCP-H100/HLMP-2685/-2785/-2885 SERIES

Features

- **FACTORY INSTALLATION SAVES TIME IN MANUFACTURING, PURCHASING AND STOCKING**
- **LIGHT OR DARK FIELD FORMAT (DARK FIELD STANDARD)**
- **HIGH STRENGTH ADHESIVE BACKING**
- **CUSTOM LEGENDS AVAILABLE**



Description

Light bar legends are available with factory installation on all light bars, using either standard or custom legends. Options L00 through L06 address our standard legend formats and can be specified for various size light bars in accordance with the Device/Option Selection Matrix.

Option Guide

Option	Legend Title
L00	ON
L01	OFF
L02	READY
L03	HIGH
L04	LOW
L05	RESET
L06	STOP

Ordering Information

To order light bar legends, include the appropriate option code along with the device catalog number. Example: to order the HLMP-2655 with the "OFF" legend, order as follows: HLMP-2655 Option L01. Minimum order quantities vary by part number.

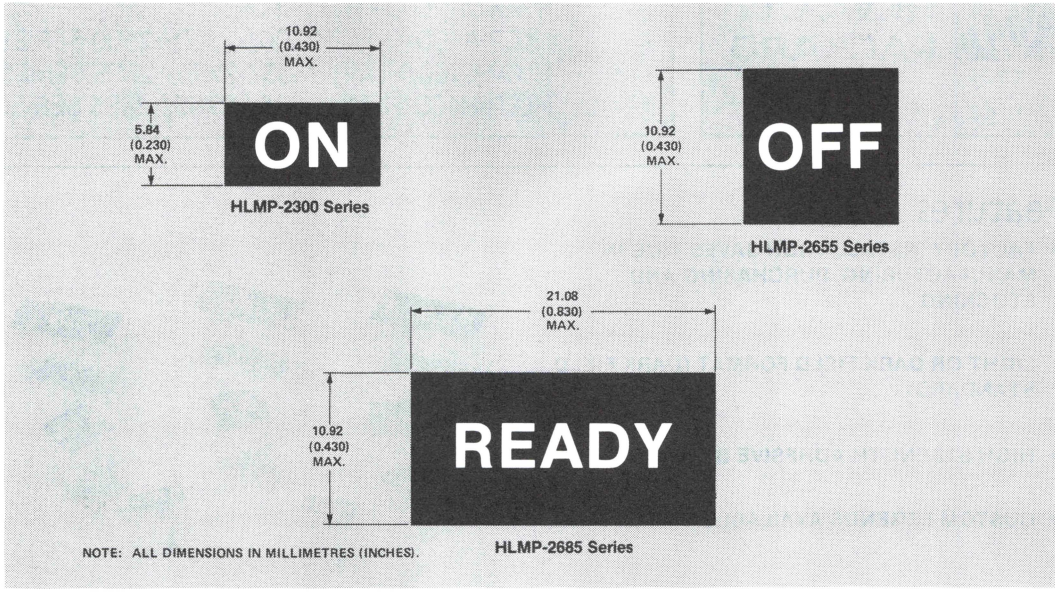
For custom legends, please contact your local Hewlett-Packard sales office or franchised Hewlett-Packard distributor.

Ratings and Characteristics

The absolute maximum ratings, mechanical dimensions and electrical characteristics for light bars with legends are the same as for the standard catalog devices. Refer to the basic data sheet for the specified values. For use in applications involving high humidity conditions, please contact your Hewlett-Packard representative.

As with the standard light bar devices, the radiation pattern is approximately Lambertion. The luminous sterance for a given device is the same as for the standard light bar products. To calculate this value, refer to the "Optical" section of the LED Light Bars data sheet in this catalog.

Dimensional Specifications for Legends



Device/Option Selection Matrix

		Applicable Light Bar Series		
Option	**Legend**	**HLMP-2300/-2400/2500 HLCP-A100**	**HLMP-2655/-2755/-2855 HLCP-C100**	**HLMP-2685/-2785/-2885 HLCP-H100**
L00	ON	X	X	X
L01	OFF	X	X	X
L02	READY			X
L03	HIGH	X	X	X
L04	LOW	X	X	X
L05	RESET			X
L06	STOP		X	X

HEWLETT PACKARD

INTENSITY SELECTED LIGHT BARS

Features

- **INTENSITY SELECTION IMPROVES UNIFORMITY OF LIGHT OUTPUT FROM UNIT TO UNIT. AVAILABLE IN HIGH EFFICIENCY RED, YELLOW, AND HIGH PERFORMANCE GREEN.**
- **TWO CATEGORY SELECTION SIMPLIFIES INVENTORY CONTROL AND ASSEMBLY.**

Description

Light bars are now available from Hewlett-Packard which are selected from two adjacent intensity categories. These select light bars are basic catalog devices which are pre-sorted for luminous intensity then selected from two predetermined adjacent categories and assigned to one convenient part number.

Example: Two luminous intensity categories are selected from the basic catalog HLMP-2300 production distribution and assigned to the part number HLMP-2300 option S02.

Selected light bars are ideal for applications which require two or more light bars per panel.

Luminous intensity selection is available for high efficiency red, yellow, and high performance green.

To ensure our customers a steady supply of product, HP must offer selected units from the center of our production distribution. If our production distribution shifts, we will need to change the intensity range of the selected units our customers receive. Typically, an intensity may have to be changed once every 1 to 3 years.

Current intensity selection information is available through a category reference chart which is available through your local field sales engineer or local franchised distributor.

Absolute Maximum Ratings and Electrical/Optical Characteristics

The absolute maximum ratings, mechanical dimensions, and electrical/optical characteristics are identical to the basic catalog device.

Device Selection Guide

The following table summarizes which basic catalog devices are available with category selection.

Package	AlGaAs Red	High Efficiency Red	Yellow	Green
4 Pin In-Line	HLCP-A100 OPT S02	HLMP-2300 OPT S02	HLMP-2400 OPT S02	HLMP-2500 OPT S02
8 Pin In-Line	HLCP-B100 OPT S02	HLMP-2350 OPT S02	HLMP-2450 OPT S02	HLMP-2550 OPT S02
8 Pin DIP Dual Arrangement	HLCP-C100 OPT S02	HLMP-2600 OPT S02	HLMP-2700 OPT S02	HLMP-2800 OPT S02
16 Pin DIP Quad Arrangement	HLCP-G100 OPT S02	HLMP-2620 OPT S02	HLMP-2720 OPT S02	HLMP-2820 OPT S02
16 Pin DIP Dual Bar Arrangement	HLCP-F100 OPT S02	HLMP-2635 OPT S02	HLMP-2735 OPT S02	HLMP-2835 OPT S02
8 Pin DIP Square Arrangement	HLCP-D100 OPT S02	HLMP-2655 OPT S02	HLMP-2755 OPT S02	HLMP-2855 OPT S02
16 Pin DIP Dual Square Arangement	HLCP-G100 OPT S02	HLMP-2670 OPT S02	HLMP-2770 OPT S02	HLMP-2870 OPT S02
16 Pin DIP Single Bar Arangement	HLCP-H100 OPT S02	HLMP-2685 OPT S02	HLMP-2785 OPT S02	HLMP-2885 OPT S02

Note: Option S02 designates a two intensity category selection. Option S02s of different part numbers may not have the same apparent brightness. Contact your HP Field Sales Office for design assistance.

Solid State Lamps

- Optional Leadform/Packaging
- AlGaAs Lamps
- Special Application Lamps
- General Purpose Lamps
- Emitters
- Hermetic Lamps

Solid State Lamps

From General to Special Purpose Lamps, Hewlett-Packard continues to grow its LED lamp product offering. This year, the broad line of lamp products is expanding in aspects of performance, packaging, and options.

Double Heterojunction Aluminum Gallium Arsenide (AlGaAs) Technology is born and bred to produce high brightness, low current lamps in subminiature, T-1, and T-1 3/4 families. In addition, a special T-1 3/4 version offers 1 Candela (1000 mcd) performance.

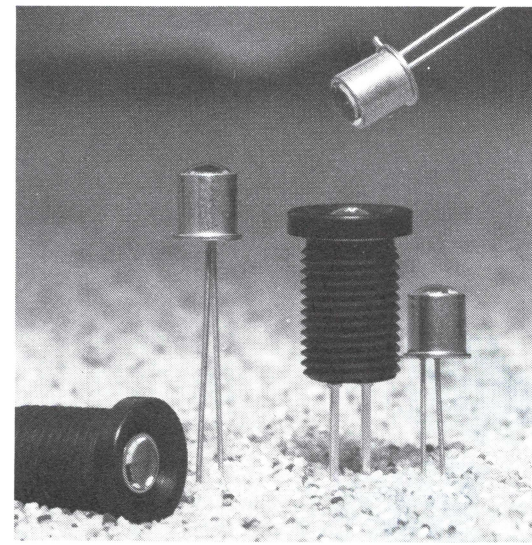
New packages are always an area of growth and importance to designers and Hewlett-Packard. That's why HP has introduced a family of 2 mm x 5 mm lamps, 940 nm emitter lamps, and now offers a T-1 3/4 bi-color lamp. In addition, HP offers a new T-2 lamp designed as an alternative to incandescent backlighting.

HP has responded to requests for options and variations of existing subminiature, T-1, and T-1 3/4 lamps in the past and this year is no exception. Subminiature lamp offerings grow with the addition of high brightness lamps, standard bends, and tape and reel options.

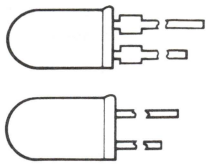
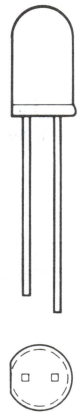
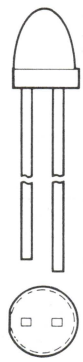
Hermetic Lamps

In addition to Hewlett-Packard commercial solid state lamps, Hewlett-Packard offers a complete line of hermetically sealed solid state lamps which are listed on MIL-S-19500 Qualified Parts List. All four colors are supplied in the basic lamp configuration, as well as the following two panel mount assembly options: Option #001 represents an anodized aluminum sleeve and Option #002 represents a conductive composite sleeve for improved EMI/RFI shielding capabilities.

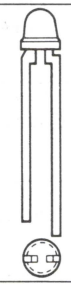
Hermetic ultra bright lamps are provided with JAN and JANTX equivalent testing, two panel mount options, and in three colors. These devices were specially designed to meet the sunlight viewability requirements of the military market.



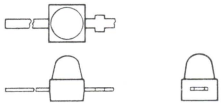
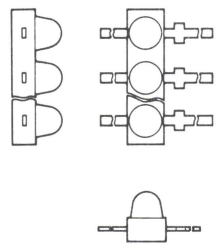
Diffused (Direct View) Lamps

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-3000	Red (640 nm)	T-1 3/4	Tinted Diffused	2.0 mcd @ 20 mA	75°	1.6 V @ 20 mA	6-69
	HLMP-3001				4.0 mcd @ 20 mA			
	HLMP-3002		Thin Leadframe		2.0 mcd @ 20 mA			
	HLMP-3003				4.0 mcd @ 20 mA			
	HLMP-3300	High Efficiency Red (626 nm)	T-1 3/4		3.5 mcd @ 10 mA	65°	2.2 V @ 10 mA	6-71
	HLMP-3301				7.0 mcd @ 10 mA			
	HLMP-3762				15.0 mcd @ 10 mA			
	HLMP-D400	Orange (608 nm)			3.5 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-D401				7.0 mcd @ 10 mA			
	HLMP-3400	Yellow (585 nm)			4.0 mcd @ 10 mA	75°	2.2 V @ 10 mA	
	HLMP-3401				8.0 mcd @ 10 mA			
	HLMP-3862				12.0 mcd @ 10 mA			
	HLMP-3502	Green (569 nm)			2.4 mcd @ 10 mA	75°	2.3 V @ 10 mA	
	HLMP-3507				5.2 mcd @ 10 mA			
	HLMP-3962				11.0 mcd @ 10 mA			
	HLMP-3200	Red (640 nm)	T-1 3/4 Low Profile	Tinted Diffused	2.0 mcd @ 20 mA	60°	1.6 V @ 20 mA	6-75
	HLMP-3201				4.0 mcd @ 20 mA			
	HLMP-3350	High Efficiency Red (626 nm)			3.5 mcd @ 10 mA	50°	2.2 V @ 10 mA	
	HLMP-3351				9.0 mcd @ 10 mA			
	HLMP-3450	Yellow (585 nm)			4.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-3451				10.0 mcd @ 10 mA			
	HLMP-3553	Green (569 nm)			3.2 mcd @ 10 mA		2.3 V @ 10 mA	
	HLMP-3554				10.0 mcd @ 10 mA			

Diffused (Direct View) Lamps (cont.)

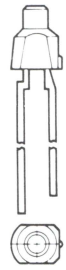
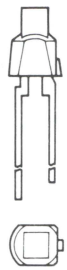
Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-1000	Red (640 nm)	T-1	Tinted Diffused	1.0 mcd @ 20 mA	60°	1.6 V @ 20 mA	6-58
	HLMP-1002				2.5 mcd @ 20 mA			
	HLMP-1080			Untinted Diffused	1.5 mcd @ 20 mA			
	HLMP-1300	High Efficiency Red (626 nm)		Tinted Diffused	2.0 mcd @ 10 mA	60°	2.2 V @ 10 mA	6-60
	HLMP-1301				2.5 mcd @ 10 mA			
	HLMP-1302				4.0 mcd @ 10 mA			
	HLMP-1385				10.0 mcd @ 10 mA			
	HLMP-K400	Orange (608 nm)			2.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-K401				2.5 mcd @ 10 mA			
	HLMP-K402				4.0 mcd @ 10 mA			
	HLMP-1400	Yellow (585 nm)			2.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-1401				3.0 mcd @ 10 mA			
	HLMP-1402				4.0 mcd @ 10 mA			
	HLMP-1485				10.0 mcd @ 10 mA			
	HLMP-1503	Green (569 nm)			2.0 mcd @ 10 mA		2.3 V @ 10 mA	
	HLMP-1523				4.0 mcd @ 10 mA			
	HLMP-1585				6.0 mcd @ 10 mA			
	HLMP-1200	Red (640 nm)	T-1 Low Profile	Untinted Non-Diffused	1.0 mcd @ 20 mA	120°	1.6 V @ 20 mA	6-58
	HLMP-1201				2.5 mcd @ 20 mA			
	HLMP-1350	High Efficiency Red (626 nm)		Tinted Diffused	2.0 mcd @ 10 mA	54°	2.2 V @ 10 mA	
	HLMP-1450	Yellow (585 nm)					2.2 V @ 10 mA	
	HLMP-1550	Green (569 nm)					2.3 V @ 10 mA	

Diffused (Direct View) Lamps (cont.)

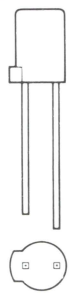
Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-6000	Red (640 nm)	Subminiature	Tinted Diffused	1.2 mcd @ 10 mA	90°C	1.6 V @ 10 mA	6-38
	HLMP-6001				3.2 mcd @ 10 mA			
	HLMP-6300	High Efficiency Red (626 nm)			3.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-6305	High Efficiency Red		Untinted Non-Diffused	12 mcd @ 10 mA	70°	2.2 V @ 10 mA	6-32
	HLMP-Q400	Orange (608 nm)		Tinted Diffused	3.0 mcd @ 10 mA	90°	2.2 V @ 10 mA	6-38
	HLMP-6400	Yellow (585 nm)					2.2 V @ 10 mA	
	HLMP-6405			Untinted Non-Diffused	12 mcd @ 10 mA	70°	2.2 V @ 10 mA	6-32
	HLMP-6500	Green (569 nm)		Tinted Diffused	3.0 mcd @ 10 mA	90°	2.2 V @ 10 A	6-38
	HLMP-6505		*	Untinted Non-Diffused	12 mcd @ 10 mA	70°	2.3 V @ 10 mA	6-32
	HLMP-6203 HLMP-6204 HLMP-6205 HLMP-6206 HLMP-6208	Red (640 nm)	3 4 5 6 8	Tinted Diffused	1.2 mcd @ 10 mA	90°	1.6 V @ 10 mA	6-43
	HLMP-6653 HLMP-6654 HLMP-6655 HLMP-6656 HLMP-6658	High Efficiency Red (626 nm)	3 4 5 6 8		3.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-6753 HLMP-6754 HLMP-6755 HLMP-6756 HLMP-6758	Yellow (585 nm)	3 4 5 6 8				2.2 V @ 10 mA	
	HLMP-6853 HLMP-6854 HLMP-6855 HLMP-6856 HLMP-6858	Green (569 nm)	3 4 5 6 8				2.3 V @ 10 mA	

*Array Length

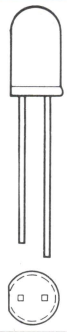
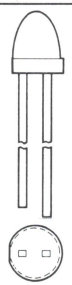
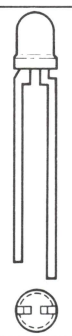
2mm Flat Top Lamps

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-1800	High Efficiency Red (626 nm)	2mm Flat Top, Round Emitting Surface	Tinted Diffused	1.8 mcd @ 10 mA	140°	2.2 V @ 10 mA	6-44
	HLMP-1801				2.9 mcd @ 10 mA			
	HLMP-1819	Yellow (585 nm)			1.5 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-1820				2.5 mcd @ 10 mA			
	HLMP-1840	Green (569 nm)			2.0 mcd @ 10 mA		2.3 V @ 10 mA	
	HLMP-1841				3.0 mcd @ 10 mA			
	HLMP-L250	High Efficiency Red (626 nm)	2mm Flat Top, Square Emitting Surface	Tinted Diffused	1.8 mcd @ 10 mA	140°	2.2 V @ 10 mA	6-50
	HLMP-L251				2.9 mcd @ 10 mA			
	HLMP-L350	Yellow (585 nm)			1.5 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-L351				2.5 mcd @ 10 mA			
	HLMP-L550	Green (569 nm)			2.0 mcd @ 10 mA		2.3 V @ 10 mA	
	HLMP-L551				3.0 mcd @ 10 mA			

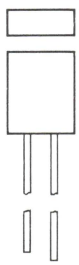
4mm Flat Top Lamps

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-M200	High Efficiency Red (626 nm)	4mm Flat Top	Tinted Diffused	5.0 mcd @ 20 mA	150°	2.2 V @ 10 mA	6-54
	HLMP-M201				7.0 mcd @ 20 mA			
	HLMP-M250			Tinted Non-Diffused	5.0 mcd @ 10 mA			
	HLMP-M251				7.0 mcd @ 10 mA			
	HLMP-M300	Yellow (585 nm)		Tinted Diffused	5.0 mcd @ 20 mA		2.2 V @ 10 mA	
	HLMP-M301				7.0 mcd @ 20 mA			
	HLMP-M350			Tinted Non-Diffused	5.0 mcd @ 10 mA			
	HLMP-M351				7.0 mcd @ 10 mA			
	HLMP-M500	Green (569 nm)		Tinted Diffused	7.0 mcd @ 20 mA		2.3 V @ 10 mA	
	HLMP-M501				10.0 mcd @ 20 mA			
	HLMP-M550			Tinted Non-Diffused	10.0 mcd @ 10 mA			
	HLMP-M551				16.0 mcd @ 10 mA			

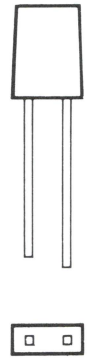
High Intensity Lamps

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-3050	Red (640 nm)	T-1 3/4	Tinted Non-Diffused	2.5 mcd @ 20 mA	24°	1.6 V @ 20 mA	6-69
	HLMP-3315	High Efficiency Red (626 nm)			18.0 mcd @ 10 mA	35°	2.2 V @ 10 mA	6-81
	HLMP-3316				30.0 mcd @ 10 mA			
	HLMP-3415	Yellow (585 nm)			18.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-3416				30.0 mcd @ 10 mA			
	HLMP-3517	Green (569 nm)			10.0 mcd @ 10 mA	24°	2.3 V @ 10 mA	
	HLMP-3519				25.0 mcd @ 10 mA			
	HLMP-3365	High Efficiency Red (626 nm)	T-1 3/4 Low Profile	Tinted Non-Diffused	10.0 mcd @ 10 mA	45°	2.2 V @ 10 mA	6-75
	HLMP-3366				18.0 mcd @ 10 mA			
	HLMP-3465	Yellow (585 nm)			12.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-3466				18.0 mcd @ 10 mA			
	HLMP-3567	Green (569 nm)			7.0 mcd @ 10 mA	40°	2.3 V @ 10 mA	
	HLMP-3568				15.0 mcd @ 10 mA			
	HLMP-1071	Red (640 nm)	T-1	Untinted Non-Diffused	2.0 mcd @ 20 mA	45°	1.6 V @ 20 mA	6-58
	HLMP-1320	High Efficiency Red (626 nm)			12.0 mcd @ 10 mA	45°	2.2 V @ 10 mA	6-65
	HLMP-1321			Tinted Non-Diffused				
	HLMP-1420	Yellow (585 nm)		Untinted Non-Diffused	12.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-1421			Tinted Non-Diffused				
	HLMP-1520	Green (569 nm)		Untinted Non-Diffused	12.0 mcd @ 10 mA		2.3 V @ 10 mA	
	HLMP-1521			Tinted Diffused				

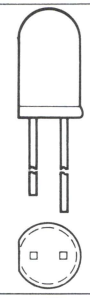
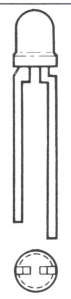
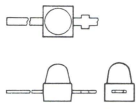
Rectangular Lamps

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-0300	High Efficiency Red (626 nm)	Rectangular	Tinted Diffused	2.5 mcd @ 20 mA	100°	2.2 V @ 20 mA	6-95
	HLMP-0301				5.0 mcd @ 20 mA			
	HLMP-0400	Yellow (585 nm)			2.5 mcd @ 20 mA		2.2 V @ 20 mA	
	HLMP-0401				5.0 mcd @ 20 mA			
	HLMP-0503	Green (569 nm)			2.5 mcd @ 20 mA		2.3 V @ 20 mA	
	HLMP-0504				5.0 mcd @ 20 mA			

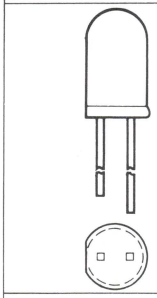
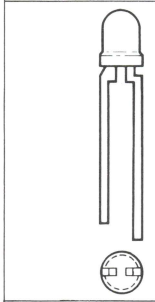
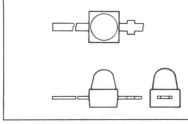
2 mm x 5 mm Rectangular Lamps

Device		Description			Typical Luminous Intensity	2θ1/2[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-S200	High Efficiency Red (626 nm)	2 mm x 5 mm Rectangular	Tinted Diffused	3.5 mcd @ 20 mA	110°	2.2 V @ 20 mA	6-91
	HLMP-S201				4.8 mcd @ 20 mA			
	HLMP-S300	Yellow (585 nm)			2.1 mcd @ 20 mA		2.2 V @ 20 mA	
	HLMP-S301				3.5 mcd @ 20 mA			
	HLMP-S400	Orange (608 nm)			3.5 mcd @ 20 mA		2.2 V @ 20 mA	
	HLMP-S401				4.8 mcd @ 20 mA			
	HLMP-S500	Green (569 nm)			4.0 mcd @ 20 mA		2.3 V @ 20 mA	
	HLMP-S501				5.8 mcd @ 20 mA			

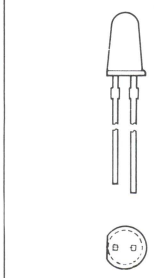
AlGaAs Lamps

Device		Description			Typical Luminous Intensity	2θ1/2[1]	Maximum Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-D101	AlGaAs Red (637 nm)	T-1 3/4	Tinted Diffused	70 mcd @ 20 mA	65°	2.2 V @ 20 mA	6-20
	HLMP-D105				240 mcd @ 20 mA	24°		
	HLMP-K101		T-1		45 mcd @ 20 mA	60°	2.2 V @ 20 mA	
	HLMP-K105				65 mcd @ 20 mA	45°		
	HLMP-Q101		Subminiature		45 mcd @ 20 mA	70°	2.2 V @ 20 mA	

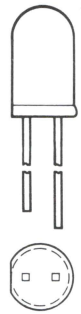
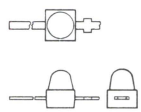
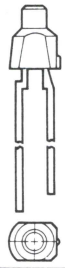
Low Current AlGaAs Lamps

Device		Description			Typical Luminous Intensity	2Θ1/2[1]	Maximum Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-D150	AlGaAs Red (637 nm)	T-1 3/4	Tinted Diffused	3.0 mcd @ 1 mA	65°	3.0 V @ 20 mA	6-24
	HLMP-D155				10 mcd @ 1 mA	24°		
	HLMP-K150		T-1		2.0 mcd @ 1 mA	60°	3.0 V @ 20 mA	
	HLMP-K155				3.0 mcd @ 1 mA	45°		
	HLMP-Q150		Subminiature		1.8 mcd @ 1 mA	70°	3.0 V @ 20 mA	

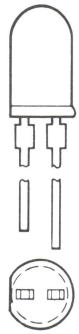
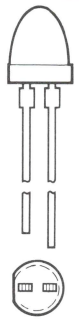
Very High Intensity AlGaAs Lamps

Device		Description			Typical Luminous Intensity	2Θ1/2	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens				
	HLMP-4100	AlGaAs Red (637 nm)	T-1 3/4	Untinted Non-Diffused	750 mcd @ 20 mA	8°	1.8 V @ 20 mA	6-28
	HLMP-4101				1000 mcd @ 20 mA			

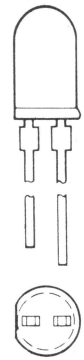
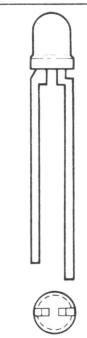
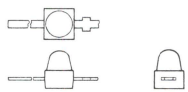
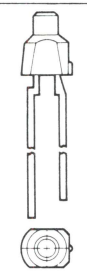
Low Current Lamps

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-4700	High Efficiency Red (626 nm)	T-1 3/4	Tinted Diffused	2.0 mcd @ 2 mA	50°	1.8 V @ 2 mA	6-102
	HLMP-4719	Yellow (585 nm)			1.8 mcd @ 2 mA		1.9 V @ 2 mA	
	HLMP-4740	Green (569 nm)			1.8 mcd @ 2 mA		1.8 V @ 2 mA	
	HLMP-1700	High Efficiency Red (626 nm)	T-1	Tinted Diffused	1.8 mcd @ 2 mA	50°	1.8 V @ 2 mA	
	HLMP-1719	Yellow (585 nm)			1.6 mcd @ 2 mA		1.9 V @ 2 mA	
	HLMP-1790	Green (569 nm)			1.6 mcd @ 2 mA		1.8 V @ 2 mA	
	HLMP-7000	High Efficiency Red (626 nm)	Subminiature	Tinted Diffused	0.8 mcd @ 2 mA	90°	1.8 V @ 2 mA	
	HLMP-7019	Yellow (585 nm)			0.6 mcd @ 2 mA		1.9 V @ 2 mA	
	HLMP-7040	Green (569 nm)			0.6 mcd @ 2 mA		1.8 V @ 2 mA	
	HLMP-1740	High Efficiency Red (626 nm)	2 mm Flat Top, Round Emitting Surface	Tinted Diffused	0.5 mcd @ 2 mA	140°	1.8 V @ 2 mA	6-44
	HLMP-1760	Yellow (585 nm)			0.4 mcd @ 2 mA		1.9 V @ 2 mA	

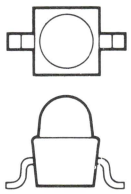
Ultrabright Lamps

Device		Description			Typical Luminous Intensity	2θ1/2[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-3750	High Efficiency Red (626 nm)	T-1 3/4	Untinted Non-Diffused	125 mcd @ 20 mA	24°	2.2 V @ 20 mA	6-98
	HLMP-3850	Yellow (585 nm)			140 mcd @ 20 mA		2.2 V @ 20 mA	
	HLMP-3950	Green (569 nm)			120 mcd @ 20 mA		2.3 V @ 20 mA	
	HLMP-3390	High Efficiency Red (626 nm)	T-1 3/4 Low Profile	Untinted Non-Diffused	55 mcd @ 20 mA	32°	2.2 V @ 20 mA	
	HLMP-3490	Yellow (585 nm)					2.2 V @ 20 mA	
	HLMP-3590	Green (569 nm)					2.3 V @ 20 mA	
	HLMP-1340	High Efficiency Red (626 nm)	T-1 Low Profile	Untinted Non-Diffused	35 mcd @ 20 mA	45°	2.2 V @ 20 mA	
	HLMP-1440	Yellow (585 nm)					2.2 V @ 20 mA	
	HLMP-1540	Green (569 nm)					2.3 V @ 20 mA	

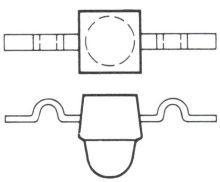
Integrated Resistor Lamps

Device		Description			Typical Luminous Intensity	2θ1/2[1]	Typical Forward Current	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-3105	Red (640 nm)	T-1 3/4	Tinted Diffused	2 mcd @ 5 V	75°	13 mA @ 5 V	6-106
	HLMP-3112				2 mcd @ 12 V		13 mA @ 12 V	
	HLMP-3600	High Efficiency Red (626 nm)			4 mcd @ 5 V	65°	10 mA @ 5 V	
	HLMP-3601				4 mcd @ 12 V		13 mA @ 12 V	
	HLMP-3650	Yellow (585 nm)			4 mcd @ 5 V	75°	10 mA @ 5 V	
	HLMP-3651				4 mcd @ 12 V		13 mA @ 12 V	
	HLMP-3680	Green (569 nm)			4 mcd @ 5 V		12 mA @ 5 V	
	HLMP-3681				4 mcd @ 12 V		13 mA @ 12 V	
	HLMP-1100	Red (640 nm)	T-1	Tinted Diffused	1.5 mcd @ 5 V	60°	13 mA @ 5 V	
	HLMP-1120			Untinted Diffused		50°		
	HLMP-1600	High Efficiency Red (626 nm)		Tinted Diffused	4 mcd @ 5 V	60°	10 mA @ 5 V	
	HLMP-1601				4 mcd @ 12 V		13 mA @ 12 V	
	HLMP-1620	Yellow (585 nm)			4 mcd @ 5 V		10 mA @ 5 V	
	HLMP-1621				4 mcd @ 12 V		13 mA @ 12 V	
	HLMP-1640	Green (569 nm)			4 mcd @ 5 V		12 mA @ 5 V	
	HLMP-1641				4 mcd @ 12 V		13 mA @ 12 V	
	HLMP-6600	High Efficiency Red (626 nm)	Subminiature	Tinted Diffused	5.0 mcd @ 5 V	90°	10 mA @ 5 V	6-110
	HLMP-6620				2.0 mcd @ 5 V		3.5 mA @ 5 V	
	HLMP-6700	Yellow (585 nm)			5.0 mcd @ 5 V		10 mA @ 5 V	
	HLMP-6720				2.0 mcd @ 5 V		2.5 mcd @ 5 V	
	HLMP-6800	Green (569 nm)			5.0 mcd @ 5 V		10 mA @ 5 V	
	HLMP-6820				2.0 mcd @ 5 V		3.5 mA @ 5 V	
	HLMP-1660	High Efficiency Red (626 nm)	2mm Flat Top, Round Emitting Surface	Tinted Diffused	1.0 mcd @ 5V	140°	10 mA @ 5V	6-44
	HLMP-1661				1.0 mcd @ 12 V		13 mA @ 5 V	
	HLMP-1674	Yellow (585 nm)			1.0 mcd @ 5 V		10 mA @ 5 V	
	HLMP-1675				1.0 mcd @ 12 V		13 mA @ 12 V	
	HLMP-1687	Green (569 nm)			1.0 mcd @ 5 V		10 mA @ 5 V	
	HLMP-1688				1.0 mcd @ 12 V		13 mA @ 12 V	

Surface Mount Lamps (Gull Wing Lead)

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-6000 Option 011	Red (640 nm)	Subminiature Gull Wing Lead Configuration	Tinted Diffused	1.2 mcd @ 10 mA	90°	1.6 V @ 10 mA	6-122
	HLMP-6300 Option 011	High Efficiency Red (626 nm)			3.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-6400 Option 011	Yellow (585 nm)					2.2 V @ 10 mA	
	HLMP-6500 Option 011	Green (569 nm)					2.3 V @ 10 mA	
	HLMP-7000 Option 011	Low Current High Efficiency Red (626 nm)			0.8 mcd @ 2 mA	70°	1.8 V @ 2 mA	
	HLMP-7019 Option 011	Low Current Yellow (585 nm)			0.6 mcd @ 2 mA		1.9 V @ 2 mA	
	HLMP-7040 Option 011	Low Current Green (569 nm)						
	HLMP-6600 Option 011	Integrated Resistor High Efficiency Red (626 nm)			2.4 mcd @ 5 V	80°	9.6 mA @ 5 V	
	HLMP-6620 Option 011				0.6 mcd @ 5 V		3.5 mA @ 5 V	

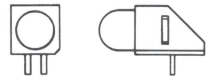
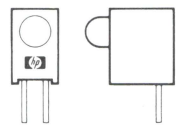
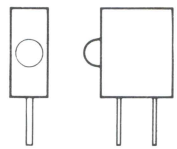
Surface Mount Lamps (Yoke Lead)

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-6000 Option 021	Red (640 nm)	Subminiature Yoke Lead Configuration	Tinted Diffused	1.2 mcd @ 10 mA	90°	1.6 V @ 10 mA	6-126
	HLMP-6300 Option 021	High Efficiency Red (626 nm)			3.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-6400 Option 021	Yellow (585 nm)					2.2 V @ 10 mA	
	HLMP-6500 Option 021	Green (569 nm)					2.3 V @ 10 mA	
	HLMP-7000 Option 021	Low Current High Efficiency Red (626 nm)			0.8 mcd @ 2 mA	70°	1.8 V @ 2 mA	
	HLMP-7019 Option 021	Low Current Yellow (585 nm)			0.6 mcd @ 2 mA		1.9 V @ 2 mA	
	HLMP-7040 Option 021	Low Current Green (569 nm)						
	HLMP-6600 Option 021	Integrated Resistor High Efficiency Red (626 nm)			2.4 mcd @ 5 V	80°	9.6 mA @ 5 V	
	HLMP-6620 Option 021				0.6 mcd @ 5 V		3.5 mA @ 5 V	

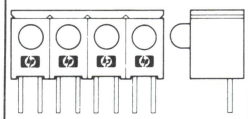
Tape and Reel: Solid State Lamps

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-3300 Option 001	High Efficiency Red (626 nm)	T-1 3/4	Tinted Diffused	3.5 mcd @ 10 mA	65°	2.2 V @ 10 mA	6-132
	HLMP-3300 Option 002							
	HLMP-1301 Option 001		T-1		2.5 mcd @ 10 mA	60°		
	HLMP-1301 Option 002							

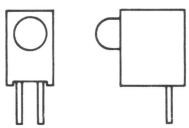
Right Angle Indicators without current limiting resistor

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-3001 Option 010	Red (640 nm)	T-1 3/4 Right Angle Indicator	Red Diffused	4.0 mcd @ 20 mA	75°	1.6 V @ 20 mA	6-139
	HLMP-3300 Option 010	High Efficiency Red (626 nm)			6.0 mcd @ 10 mA	65°	2.2 V @ 10 mA	
	HLMP-3400 Option 010	Yellow (585 nm)		Yellow Diffused	6.0 mcd @ 10 mA	75°	2.2 V @ 10 mA	
	HLMP-3502 Option 010	Green (569 nm)		Green Diffused	2.4 mcd @ 10 mA	75°	2.3 V @ 10 mA	
	HLMP-1002 Option 010	Red (640 nm)	T-1 Right Angle Indicator	Red Diffused	2.5 mcd @ 20 mA	125°	1.6 V @ 20 mA	6-137
	HLMP-1301 Option 010	High Efficiency Red (626 nm)			2.5 mcd @ 10 mA	60°	2.2 V @ 10 mA	
	HLMP-1401 Option 010	Yellow (585 nm)		Yellow Diffused	3.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-1503 Option 010	Green (569 nm)		Green Diffused	2.0 mcd @ 10 mA		2.3 V @ 10 mA	
	HLMP-6000 Option 010	Red (640 nm)	Subminiature Right Angle Indicator	Red Diffused	1.2 mcd @ 10 mA	90°	1.6 V @ 10 mA	6-136
	HLMP-6300 Option 010	High Efficiency Red (626 nm)			3.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-6400 Option 010	Yellow (585 nm)		Yellow Diffused			2.2 V @ 10 mA	
	HLMP-6500 Option 010	Green (569 nm)		Green Diffused			2.3 V @ 10 mA	

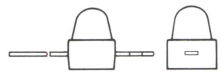
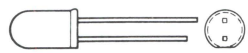
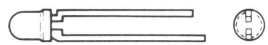
Right Angle Indicators without current limiting resistor (cont.)

Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-1301 Option 104	High Efficiency Red (626 nm)	T-1 Right Angle Indicator 4-Element Array	Tinted Diffused	2.5 mcd @ 10 mA	60°	2.2 V @ 10 mA	6-138
	HLMP-1401 Option 104	Yellow (585 nm)			3.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-1503 Option 104	Green (569 nm)			2.0 mcd @ 10 mA		2.2 V @ 10 mA	
	HLMP-5029	Right Angle Housing for T-1 3/4 Lamps						6-141

Right Angle Indicators with current limiting resistor

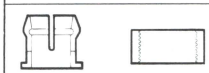
Device		Description			Typical Luminous Intensity	$2\theta 1/2$[1]	Typical Forward Current	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-3112 Option 010	Red (640 nm)	T-1 3/4 Right Angle Indicator	Red Diffused	2 mcd @ 12V	75°	13 mA @ 12 V	6-139
	HLMP-3105 Option 010				2 mcd @ 5 V		13 mA @ 5 V	
	HLMP-3600 Option 010	High Efficiency Red (626 nm)			4 mcd @ 5 V	65°	10 mA @ 5 V	
	HLMP-3650 Option 010	Yellow (585 nm)		Yellow Diffused		75°	10 mA @ 5 V	
	HLMP-3680 Option 010	Green (569 nm)		Green Diffused			12 mA @ 5 V	
	HLMP-1100 Option 010	Red (640 nm)	T-1 Right Angle Indicator	Red Diffused	1.5 mcd @ 5 V	60°	13 mA @ 5 V	6-137
	HLMP-1600 Option 010	High Efficiency Red (626 nm)			4 mcd @ 5 V		10 mA @ 5 V	
	HLMP-1620 Option 010	Yellow (585 nm)		Yellow Diffused			10 mA @ 5 V	
	HLMP-1640 Option 010	Green (569 nm)		Green Diffused			12 mA @ 5 V	

Emitter Components

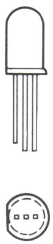
Device		Description	Features	Page No.
Package Outline Drawing	Part No.			
	HEMT-6000	700 nm High Intensity Subminiature Emitter	• Visible (Near IR) emmision facilitates alignment. • Compatible with most silicon phototransistors and photodiodes.	6-122
	HEMT-3301	940 nm T-1 3/4 High Radiant Emitter	• Efficiency at Low Currents • Radiated spectrum matches response of silicon photodetectors • Non-saturated, high radiant flux output	6-116
	HEMT-1001	940 nm T-1 High Radiant Emitter		

Notes: 1) 2θ1/2 is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2) Dominant wavelength

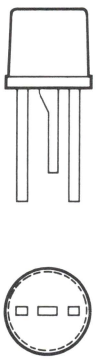
Mounting Hardware

Device		Description	Page No.
Package Outline Drawing	Part No.		
	HLMP-0103	Mounting Clip and Ring for T-1 3/4 Lamps	6-144

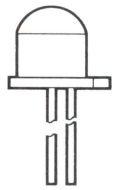
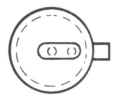
T-1 3/4 Bicolor Solid State Lamp

Device		Description			Typical Luminous Intensity	2Θ1/2	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens				
	HLMP-4000	High Efficiency Red (626 nm)	T-1 3/4	Untinted Diffused	5.0 mcd @ 10 mA	65°	2.1 V @ 10 mA	6-113
		Green (569 nm)			8.0 mcd @ 10 mA		2.3 V @ 10 mA	

T-2 Incandescent Alternative Lamps

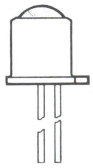
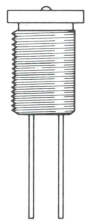
Device		Description			Typical Luminous Intensity	2Θ1/2	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color	Package	Lens				
	HLMP-A200	High Efficiency Red (626 nm)	T-2	Tinted Non-Diffused	40 mcd @ 50 mA	114°	4.2 V @ 50 mA	6-85
	HLMP-A300	Yellow (585 nm)			40 mcd @ 50 mA		4.3 V @ 50 mA	
	HLMP-A500	Green (569 nm)			40 mcd @ 50 mA	124°	4.6 V @ 50 mA	

Hermetically Sealed and High Reliability LED Lamps

Device		Description			Typical Luminous Intensity	2θ 1/2[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
 	1N5765 JAN1N5765[4] JANTX1N5765[4]	Red (640 nm)	Hermetic / TO-46[3]	Red Diffused	1.0 mcd @ 20 mA	70°	1.6 V @ 20 mA	6-146
	1N6092 JAN1N6092[4] JANTX1N6092[4]	High Efficiency Red (626 nm)			5.0 mcd @ 20 mA		2.0 V @ 20 mA	
	1N6093 JAN1N6093[4] JANTX1N6093[4]	Yellow (585 nm)		Yellow Diffused				
	1N6094 JAN1N6094[4] JANTX1N6094[4]	Green (572 nm)		Green Diffused	3.0 mcd @ 25 mA		2.1 V @ 25 mA	
	HLMP-0904 HLMP-0930 HLMP-0931	Red (640 nm)	Panel Mount Version	Red Diffused	1.0 mcd @ 20 mA		1.6 V @ 20 mA	6-146
	HLMP-0354 JANM19500/ 51901[4] JTXM19500/ 51902[4]	High Efficiency Red (626 nm)			5.0 mcd @ 20 mA		2.0 V @ 20 mA	
	HLMP-0454 JANM19500/ 52001[4] JTXM19500/ 52002[4]	Yellow (585 nm)		Yellow Diffused				
	HLMP-0554 JANM19500/ 52101[4] JTXM19500/ 52102[4]	Green (572 nm)		Green Diffused	3.0 mcd @ 25 mA		2.1 V @ 25 mA	

NOTES:
1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. Dominant Wavelength.
3. PC Board Mountable.
4. Military Approved and qualified for High Reliability Applications.

Hermetically Sealed and High Reliability LED Lamps (cont.)

Device		Description			Typical Luminous Intensity	2θ 1/2[1]	Typical Forward Voltage	Page No.
Package Outline Drawing	Part No.	Color[2]	Package	Lens				
	HLMP-0363 HLMP-0391 HLMP-0392	High Efficiency Red (626 nm)	Hermetic TO-18[3]	Clear Class	50 mcd @20 mA	18	2.0 V @ 20 mA	6-152
	HLMP-0463 HLMP-0491 HLMP-0492	Yellow (585 nm)			50 mcd @ 20 mA		2.0 V @ 20 mA	
	HLMP-0563 HLMP-0591 HLMP-0592	Green (572 nm)			50 mcd @ 25 mA		2.1 V @ 25 mA	
	HLMP-0364 HLMP-0365 HLMP-0366	High Efficiency Red (626 nm)	Panel Mount Version	Clear Glass	50 mcd @ 20 mA		2.0 V @ 20 mA	
	HLMP-0464 HLMP-0465 HLMP-0466	Yellow (585 nm)			50 mcd @ 25 mA		2.0 V @ 20 mA	
	HLMP-0564 HLMP-0565 HLMP-0566	Green (572 nm)			50 mcd @ 25 mA		2.1 V @ 25 mA	

NOTES:
1. Θ1/2 is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. Dominant Wavelength.
3. PC Board Mountable.
4. Military Approved and qualified for High Reliability Applications.

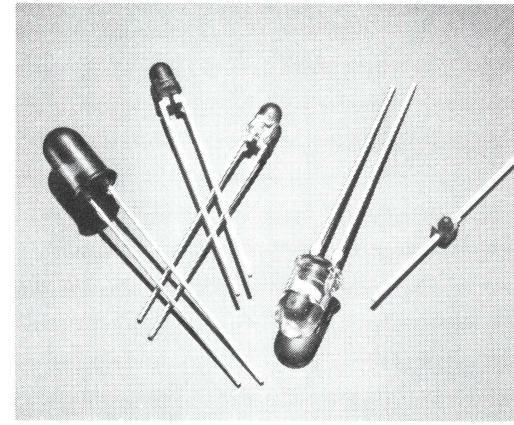
HEWLETT PACKARD

DOUBLE HETEROJUNCTION AlGaAs HIGH INTENSITY RED LED LAMPS

T-1 3/4 (5mm) HLMP-D101/D105
T-1 (3mm) HLMP-K101/K105
SUBMINIATURE HLMP-Q101

Features

- EXCEPTIONAL BRIGHTNESS
- WIDE VIEWING ANGLE
- OUTSTANDING MATERIAL EFFICIENCY
- LOW FORWARD VOLTAGE
- CMOS/MOS COMPATIBLE
- TTL COMPATIBLE
- DEEP RED COLOR



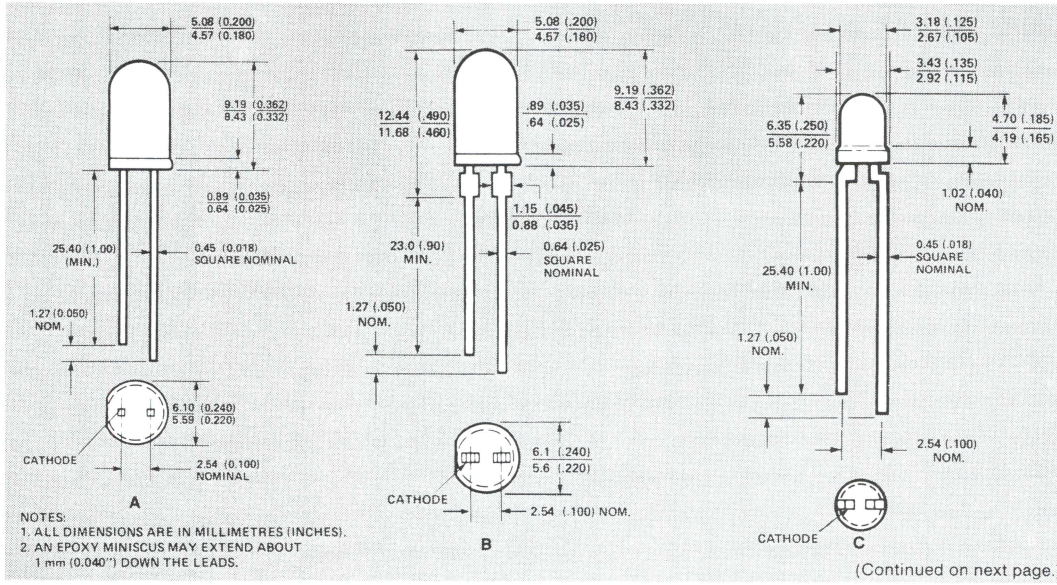
Applications

- BRIGHT AMBIENT LIGHTING CONDITIONS
- MOVING MESSAGE PANELS
- PORTABLE EQUIPMENT
- GENERAL USE

Description

These solid state LED lamps utilize newly developed double heterojunction (DH) AlGaAs/GaAs material technology. This LED material has outstanding light output efficiency over a wide range of drive currents. The color is deep red at the dominant wavelength of 637 nanometres. These lamps may be DC or pulse driven to achieve desired light output.

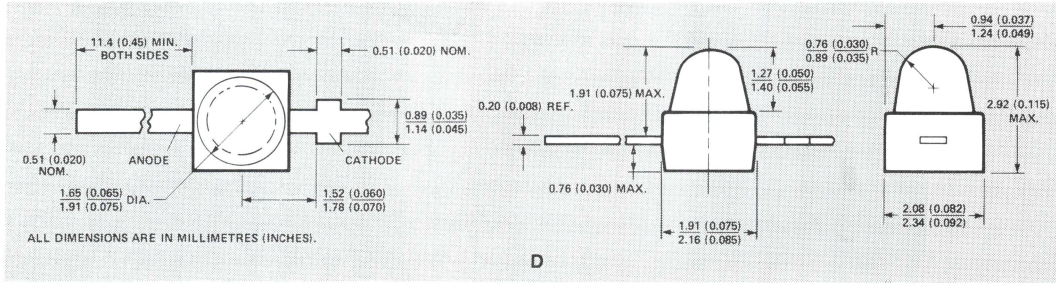
Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MINISCUS MAY EXTEND ABOUT 1 mm (0.040") DOWN THE LEADS.

(Continued on next page.)

Package Dimensions



Axial Luminous Intensity and Viewing Angle @ 25°C

Part Number HLMP-	Package Description	I_V (mcd) @ 20 mA Min.	Typ.	2θ ½ Note 1. Degrees	Package Outline
D101	T-1 ¾ Red Tinted Diffused	35	70	65	A
D105	T-1 ¾ Red Untinted, Non-diffused	100	240	24	B
K101	T-1 Red Tinted Diffused	22	45	60	C
K105	T-1 Red Untinted Non-diffused	35	65	45	C
Q101	Subminiature Red Tinted Diffused	20	45	70	D

Note:
1. θ½ is the off axis angle from lamp centerline where the luminous intensity is ½ the on-axis value.

Absolute Maximum Ratings at T_A = 25°C

Peak Forward Current[1, 2] ..... 300 mA
Average Forward Current[2] ..... 20 mA
DC Current[3] ..... 30 mA
Power Dissipation ..... 87 mW
Reverse Voltage (I_R = 100μA) ..... 5 V
Transient Forward Current (10 μs Pulse)[4] ..... 500 mA
Operating Temperature Range ..... -20 to +100° C
Storage Temperature Range ..... -55 to +100° C
Lead Soldering Temperature
[1.6 mm (0.063 in.) from body] ... 260° C for 5 seconds

Notes:
1. Maximum I_{PEAK} at f = 1 kHz, DF = 6.7%.
2. Refer to Figure 6 to establish pulsed operating conditions.
3. Derate linearly as shown in Figure 5.
4. The transient peak current is the maximum non-recurring peak current the device can withstand without damaging the LED die and wire bonds. It is not recommended that the device be operated at peak currents beyond the Absolute Maximum Peak Forward Current.

Electrical/Optical Characteristics at T_A = 25°C

Symbol	Description	Min.	Typ.	Max.	Unit	Test Condition
V_F	Forward Voltage		1.8	2.2	V	I_F = 20 mA
V_R	Reverse Breakdown Voltage	5.0	15.0		V	I_R = 100 μA
λ_p	Peak Wavelength		645		nm	Measurement at peak
λ_d	Dominant Wavelength		637		nm	Note 1
$\Delta\lambda$½	Spectral Line Halfwidth		20		nm	
τ_S	Speed of Response		30		ns	Exponential Time Constant, e^{-t/T_S}
C	Capacitance		30		pF	V_F = 0, f = 1 MHz
θ_{JC}	Thermal Resistance		220		°C/W	Junction to Cathode Lead
η_V	Luminous Efficacy		80		ℓm/W	Note 2

Notes:
1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the color of the device.
2. The radiant intensity, I_e, in watts per steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity is in candelas and η_V is luminous efficacy in lumens/watt.

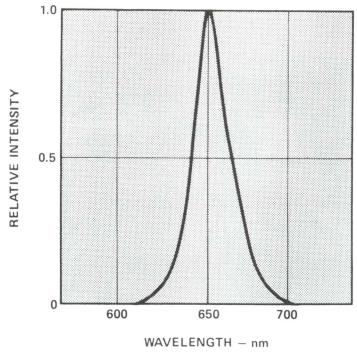


Figure 1. Relative Intensity vs. Wavelength.

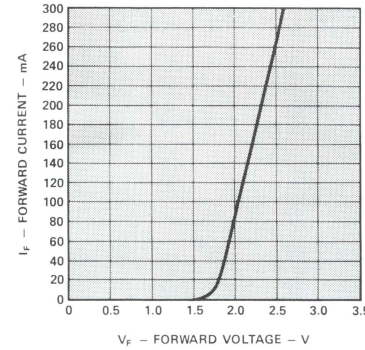


Figure 2. Forward Current vs. Forward Voltage.

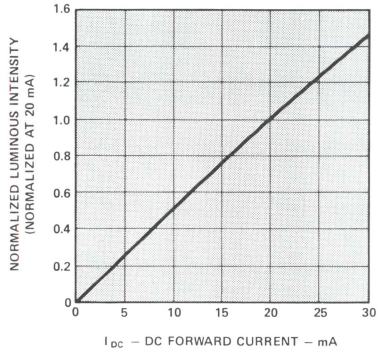


Figure 3. Relative Luminous Intensity vs. DC Forward Current.

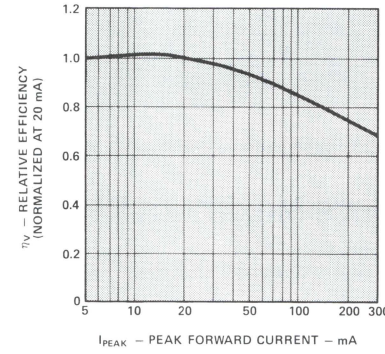


Figure 4. Relative Efficiency vs. Peak Forward Current.

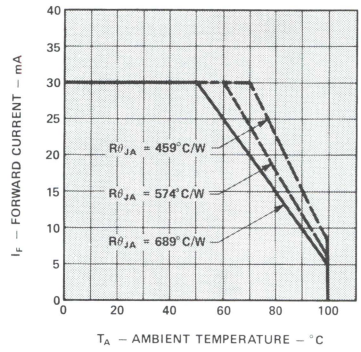


Figure 5. Maximum Forward DC Current vs. Ambient Temperature. Derating Based on T_J MAX = 110° C.

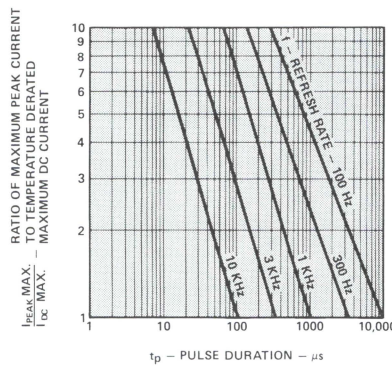


Figure 6. Maximum Tolerable Peak Current vs. Peak Duration (I_{PEAK} MAX Determined from Temperature Derated I_{DC} MAX).

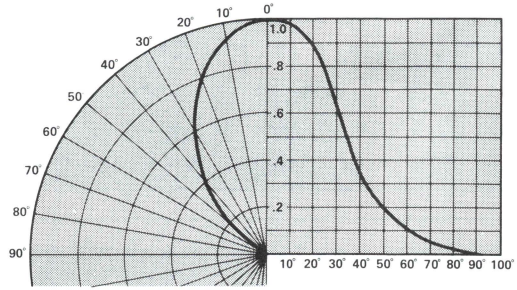


Figure 7. Relative Luminous Intensity vs. Angular Displacement. HLMP-D101.

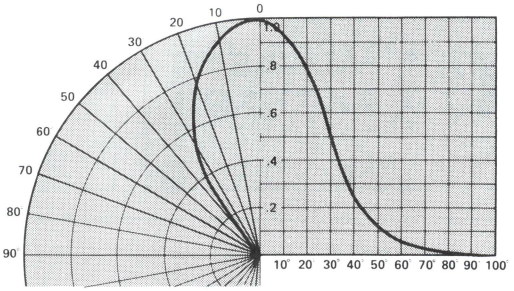


Figure 8. Relative Luminous Intensity vs. Angular Displacement. HLMP-K101.

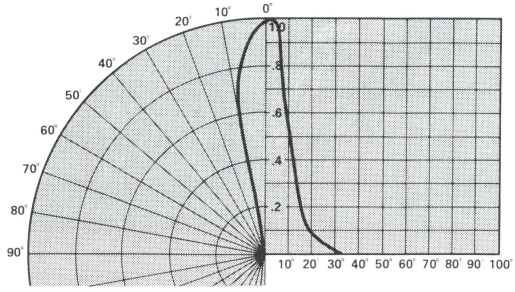


Figure 9. Relative Luminous Intensity vs. Angular Displacement. HLMP-D105.

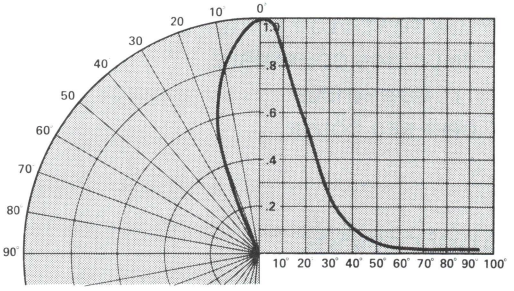


Figure 10. Relative Luminous Intensity vs. Angular Displacement. HLMP-K105.

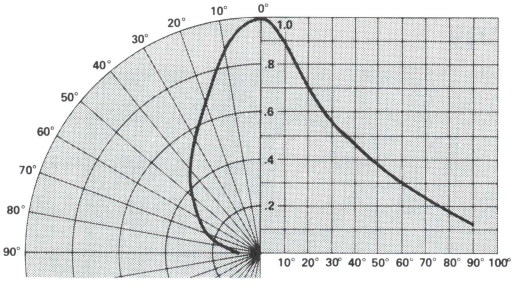


Figure 11. Relative Luminous Intensity vs. Angular Displacement for Subminiature Lamp

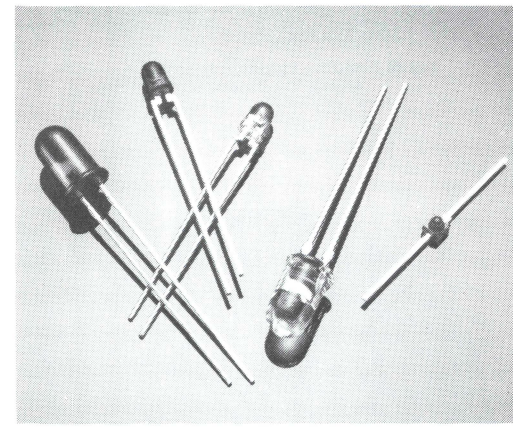
HEWLETT PACKARD

DOUBLE HETEROJUNCTION AlGaAs LOW CURRENT RED LED LAMPS

T-1 3/4 (5mm) HLMP-D150/D155
T-1 (3mm) HLMP-K150/K155
SUBMINIATURE HLMP-Q150

Features

- MINIMUM LUMINOUS INTENSITY SPECIFIED AT 1 mA
- HIGH LIGHT OUTPUT AT LOW CURRENTS
- WIDE VIEWING ANGLE
- OUTSTANDING MATERIAL EFFICIENCY
- LOW POWER/LOW FORWARD VOLTAGE
- CMOS/MOS COMPATIBLE
- TTL COMPATIBLE
- DEEP RED COLOR



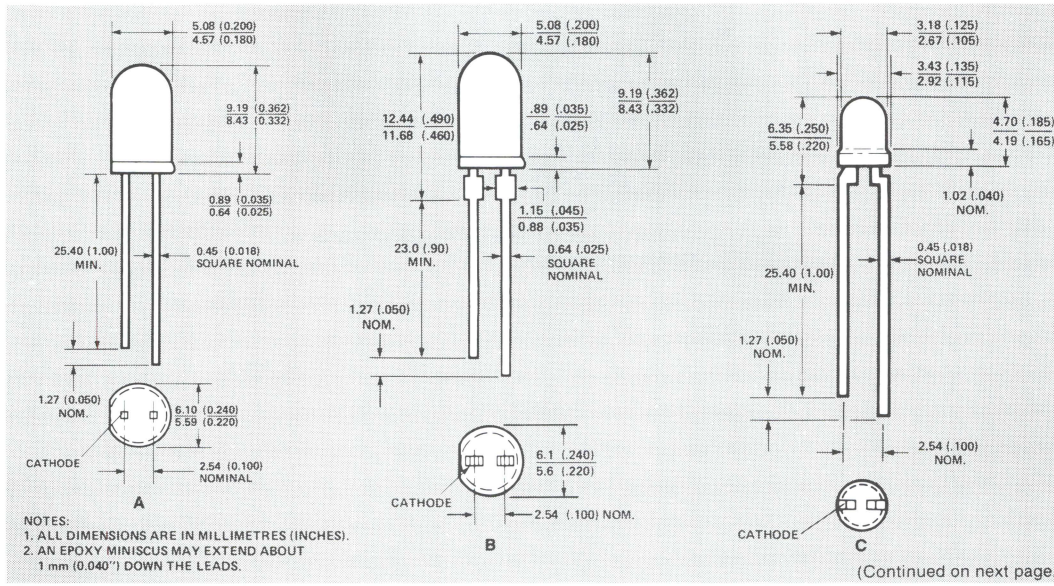
Applications

- LOW POWER CIRCUITS
- BATTERY POWERED EQUIPMENT
- TELECOMMUNICATION INDICATORS

Description

These solid state LED lamps utilize newly developed double heterojunction (DH) AlGaAs/GaAs material technology. This LED material has outstanding light output efficiency at very low drive currents. The color is deep red at the dominant wavelength of 637 nanometres. These lamps are ideally suited for use in applications where high light output is required with minimum power input.

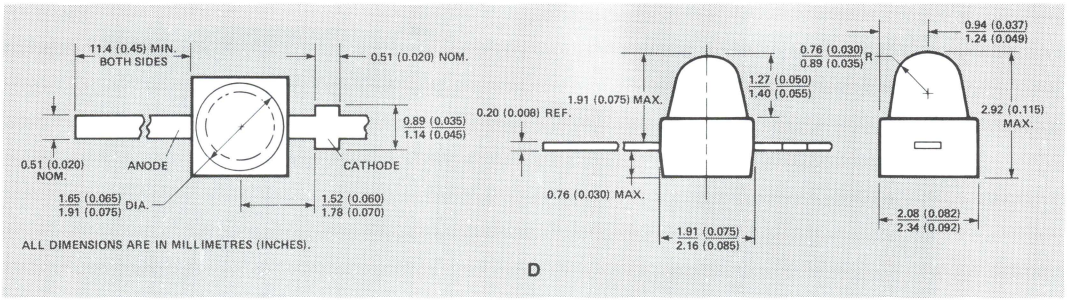
Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MINISCUS MAY EXTEND ABOUT 1 mm (0.040") DOWN THE LEADS.

(Continued on next page.)

Package Dimensions



Axial Luminous Intensity and Viewing Angle @ 25°C

Part Number HLMP-	Package Description	I_V (mcd) @ 1 mA DC Min.	Typ.	2θ ½ Note 1. Degrees	Package Outline
D150	T-1 ¾ Red Tinted Diffused	1.2	3	65	A
D155	T-1 ¾ Red Untinted, Non-diffused	5	10	24	B
K150	T-1 Red Tinted Diffused	1.2	2	60	C
K155	T-1 Red Untinted Non-diffused	2	3	45	C
Q150	Subminiature Red Tinted Diffused	1	1.8	70	D

Note:
1. θ½ is the off axis angle from lamp centerline where the luminous intensity is ½ the on-axis value.

Absolute Maximum Ratings at T_A = 25°C

Peak Forward Current[1] ..... 300 mA
Average Forward Current ..... 20 mA
DC Current[2] ..... 30 mA
Power Dissipation ..... 87 mW
Reverse Voltage (I_R = 100 μA) ..... 5 V
Transient Forward Current (10 μs Pulse)[3] ..... 500 mA
Operating Temperature Range ..... -20 to +100°C
Storage Temperature Range ..... -55 to +100°C
Lead Soldering Temperature
[1.6 mm (0.063 in.) from body] ... 260°C for 5 seconds

Notes:
1. Maximum I_{PEAK} at f = 1 kHz, DF = 6.7%.
2. Derate linearly as shown in Figure 4.
3. The transient peak current is the maximum non-recurring peak current the device can withstand without damaging the LED die and wire bonds. It is not recommended that the device be operated at peak currents beyond the Absolute Maximum Peak Forward Current.

Electrical/Optical Characteristics at T_A = 25°C

Symbol	Description	Min.	Typ.	Max.	Unit	Test Condition
V_F	Forward Voltage		1.6	1.8	V	I_F = 1 mA
V_R	Reverse Breakdown Voltage	5.0	15.0		V	I_R = 100 μA
λ_p	Peak Wavelength		645		nm	Measurement at peak
λ_d	Dominant Wavelength		637		nm	Note 1
$\Delta\lambda$½	Spectral Line Halfwidth		20		nm	
τ_S	Speed of Response		30		ns	Exponential Time Constant, e^{-t}/T_S
C	Capacitance		30		pF	V_F = 0, f = 1 MHz
θ_{JC}	Thermal Resistance		220		°C/W	Junction to Cathode Lead
η_V	Luminous Efficacy		80		ℓm/W	Note 2

Notes:
1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the color of the device.
2. The radiant intensity, I_e, in watts per steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity is in candelas and η_V is luminous efficacy in lumens/watt.

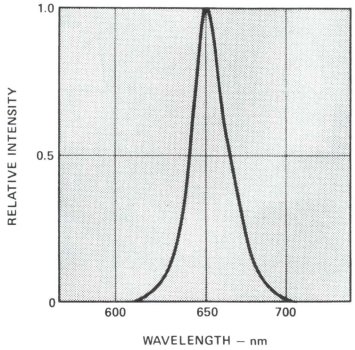


Figure 1. Relative Intensity vs. Wavelength.

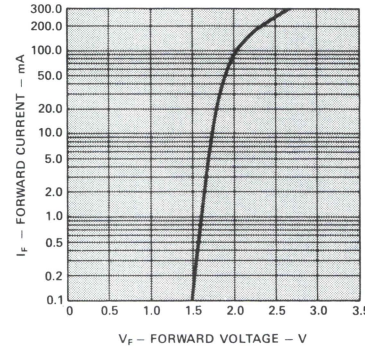


Figure 2. Forward Current vs. Forward Voltage.

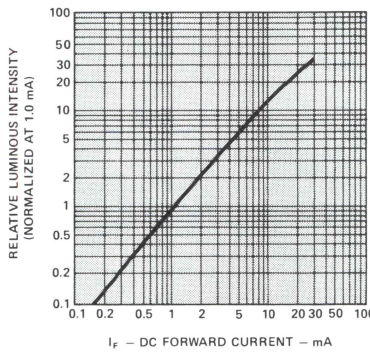


Figure 3. Relative Luminous Intensity vs. DC Forward Current.

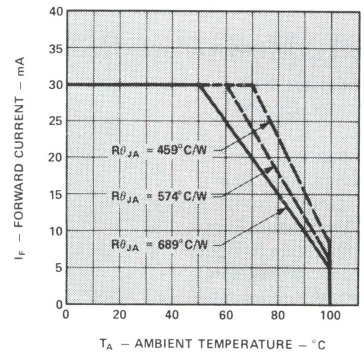


Figure 4. Maximum Forward DC Current vs. Ambient Temperature. Derating Based on T_J Max. = 110° C.

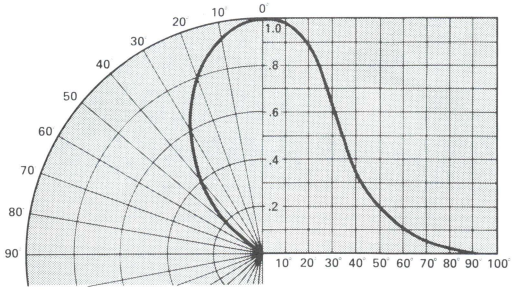


Figure 5. Relative Luminous Intensity vs. Angular Displacement. HLMP-D150.

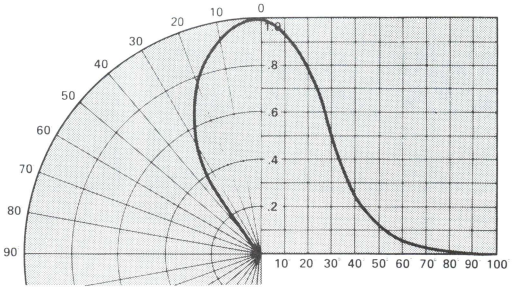


Figure 6. Relative Luminous Intensity vs. Angular Displacement. HLMP-K150.

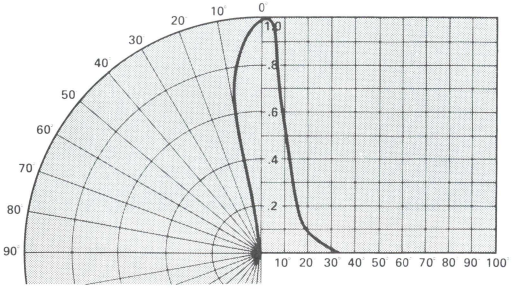


Figure 7. Relative Luminous Intensity vs. Angular Displacement. HLMP-D155.

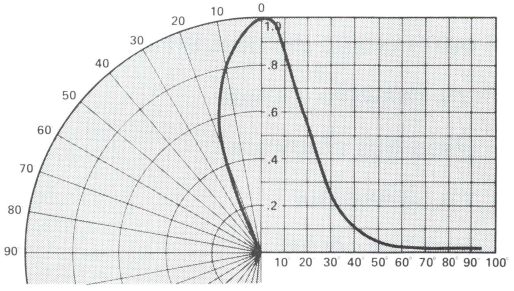


Figure 8. Relative Luminous Intensity vs. Angular Displacement. HLMP-K155.

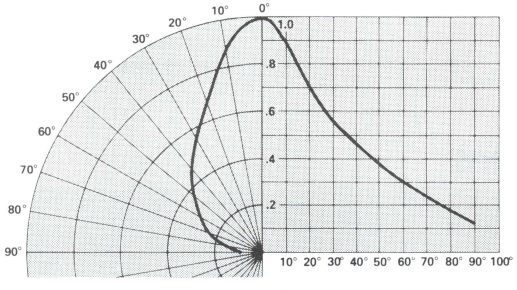


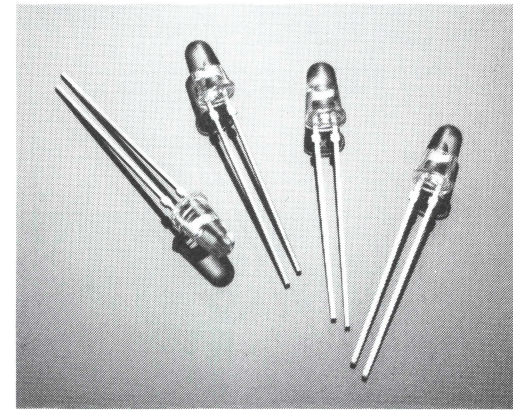
Figure 9. Relative Luminous Intensity vs. Angular Displacement for Subminiature Lamp

HEWLETT PACKARD

DOUBLE HETEROJUNCTION AlGaAs VERY HIGH INTENSITY RED LED LAMPS T-1 3/4 (5 mm) HLMP-4100,-4101

Features

- 1000 mcd AT 20 mA
- VERY HIGH INTENSITY AT LOW DRIVE CURRENTS
- NARROW VIEWING ANGLE
- OUTSTANDING MATERIAL EFFICIENCY
- LOW FORWARD VOLTAGE
- CMOS/MOS COMPATIBLE
- TTL COMPATIBLE
- DEEP RED COLOR



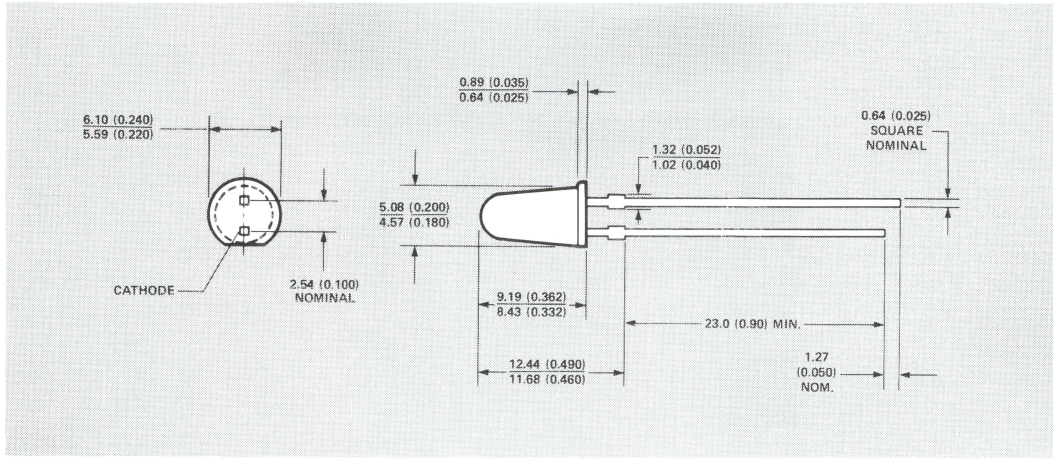
Applications

- BRIGHT AMBIENT LIGHTING CONDITIONS
- EMITTER/DETECTOR AND SIGNALING APPLICATIONS
- GENERAL USE

Description

These solid state LED lamps utilize newly developed double heterojunction (DH) AlGaAs/GaAs material technology. This LED material has outstanding light output efficiency over a wide range of drive currents. The lamp package has a tapered lens, designed to concentrate the luminous flux into a narrow radiation pattern to achieve a very high intensity. The LED color is deep red at the dominant wavelength of 637 nanometres. These lamps may be DC or pulse driven to achieve desired light output.

Package Dimensions



Luminous Intensity @ 25°C

P/N HLMP-	Package Description	I_V (mcd) @ 20 mA DC Min.	Typ.	2θ1/2 Note 1. Degrees
4100	T-1 3/4 Red Untinted, Non-diffused	500	750	8
4101		700	1000	

Note:

1. θ1/2 is the angle from optical centerline where the luminous intensity is 1/2 the optical centerline value.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	Maximum Rating	Units
Peak Forward Current[1, 2]	300	mA
Average Forward Current[2]	20	mA
DC Current[3]	30	mA
Power Dissipation	87	mW
Reverse Voltage (I_R = 100 μA)	5	V
Transient Forward Current (10 μs Pulse)[4]	500	mA
Operating Temperature Range	-20 to +100	°C
Storage Temperature Range	-55 to +100	°C
Lead Soldering Temperature [1.6 mm (0.063 in.) from body]	260° C for 5 seconds	

Notes:

1. Maximum I_{PEAK} at f = 1 kHz, DF = 6.7%.
2. Refer to Figure 6 to establish pulsed operating conditions.
3. Derate linerally as shown in Figure 5.
4. The transient peak current is the maximum non-recurring peak current the device can withstand without damaging the LED die and wire bonds. It is not recommended that the device be operated at peak currents beyond the Absolute Maximum Peak Forward Current.

Electrical/Optical Characteristics at $T_A = 25°C$

Symbol	Description	Min.	Typ.	Max.	Unit	Test Condition
V_F	Forward Voltage		1.8	2.2	V	20 mA
V_R	Reverse Breakdown Voltage	5.0	15.0		V	I_R = 100 μA
λ_{PEAK}	Peak Wavelength		650		nm	Measurement at peak
λ_d	Dominant Wavelength		642		nm	Note 1
$\Delta\lambda$ 1/2	Spectral Line Halfwidth		20		nm	
τ_S	Speed of Response		30		ns	Exponential Time Constant, $e^{-t/s}$
C	Capacitance		30		pF	V_F = 0, f = 1 MHz
θ_{jc}	Thermal Resistance		220		°C/W	Junction to Cathode Lead
η_V	Luminous Efficacy		80		lm/W	Note 2

Notes:

1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the color of the device.
2. The radiant intensity, I_e, in watts per steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is luminous efficacy in lumens/watt.
3. The approximate total luminous flux output within a cone angle of 2θ about the optical axis, $\phi_V(2\theta)$, may be obtained from the following formula:
   $\phi_V(2\theta) = [\phi_V(\theta)/I_V(0)]I_V$;
   Where: $\phi_V(\theta)/I_V(0)$ is obtained from Figure 7.

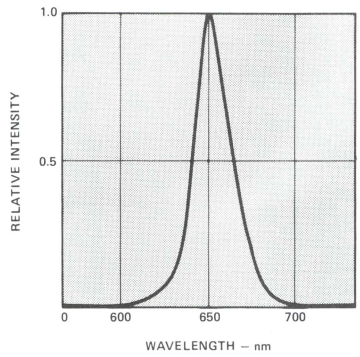


Figure 1. Relative Intensity vs. Wavelength

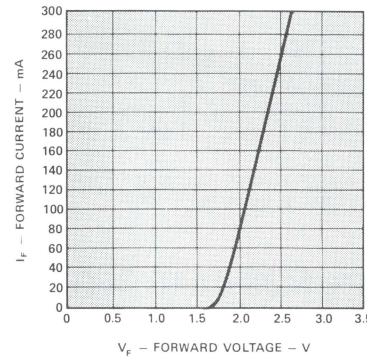


Figure 2. Forward Current vs. Forward Voltage

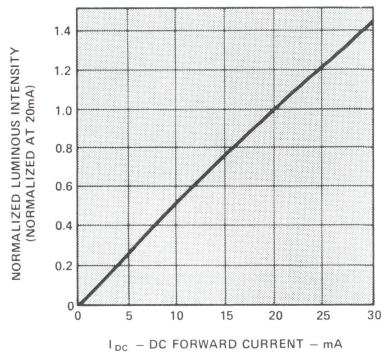


Figure 3. Relative Luminous Intensity vs. DC Forward Current

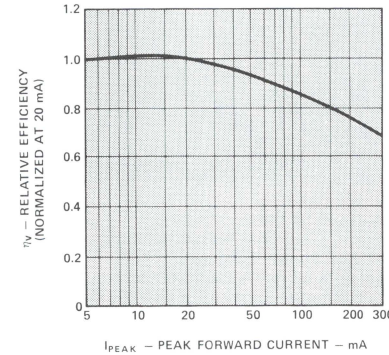


Figure 4. Relative Efficiency vs. Peak Forward Current

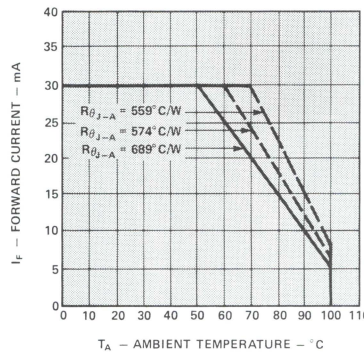


Figure 5. Maximum Forward DC Current vs. Ambient Temperature Derating Based on T_J MAX. =110° C

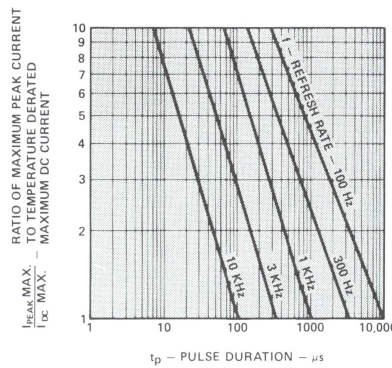


Figure 6. Maximum Tolerable Peak Current vs. Peak Duration (I_{PEAK} MAX Determined from Temperature Derated I_{DC} MAX).

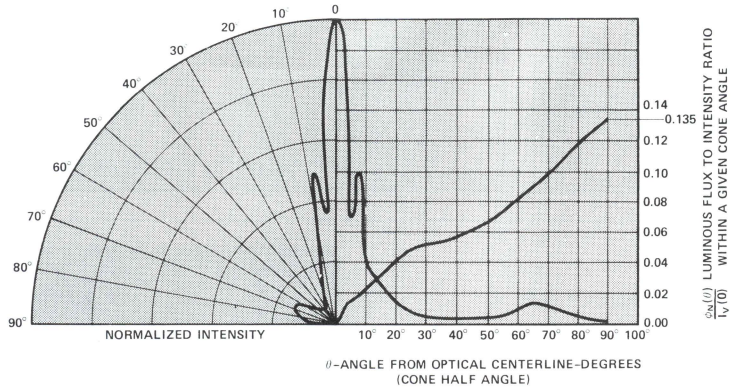


Figure 7. Relative Luminous Intensity vs. Angular Displacement

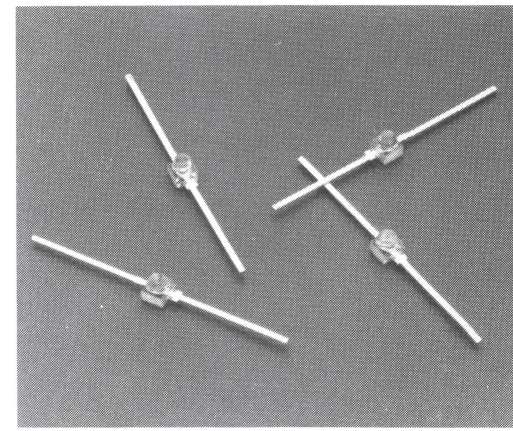
HEWLETT PACKARD

SUBMINIATURE HIGH BRIGHTNESS SOLID STATE LAMPS

High Efficiency Red • HLMP-6305
Yellow • HLMP-6405
High Performance Green • HLMP-6505

Features

- **SUBMINIATURE PACKAGE STYLE**
- **END STACKABLE**
- **LOW PACKAGE PROFILE**
- **AXIAL LEADS**
- **NARROW VIEWING ANGLE**
- **LONG LIFE — SOLID STATE RELIABILITY**
- **AVAILABLE IN BULK, ARRAYS, TAPE AND REEL, SURFACE MOUNT, AND BENT LEAD CONFIGURATIONS**



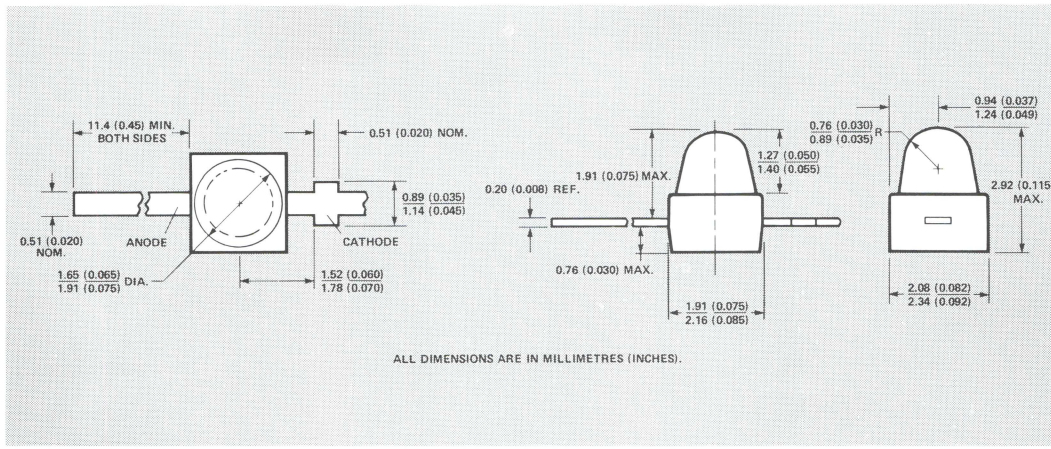
Description

Lamps in this series of solid state indicators are encapsulated in an axial lead subminiature package of molded epoxy. They utilize an untinted non-diffused lens providing superior product performance. Small size makes these lamps suitable for PC Board mounting in space sensitive applications.

Special lead bending, packaging and assembly methods can be used with these devices. Refer to the special data sheet for lead bend configurations. Two special surface mount lead configurations are also available. See the data sheets for "gull wing" and "yoke lead" options for more detailed information. Tape and reel packaging for the standard product is also available (refer to Tape and Reel Data Sheet).

Part Number HLMP-	Minimum Intensity (mcd) at 10 mA	Color (Material)
6305	3.4	High Efficiency Red (GaP on GaAsP)
6405	3.6	Yellow (GaP on GaAsP)
6505	4.2	Green (GaP)

Package Dimensions



Electrical Characteristics at $T_A = 25°C$

Symbol	Parameter	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	High Efficiency Red 6305	3.4	12		mcd	I_F = 10 mA (Figures 3, 8, 13)
		Yellow 6405	3.6	12			
		Green 6505	4.2	12			
$2\Theta_{1/2}$	Including Angle Between Half Luminous Intensity Points	All		28		Deg.	See Note 1 (Figures 6, 11, 16)
λ_{PEAK}	Peak Wavelength	High Efficiency Red		635		nm	Measurement at Peak
		Yellow		583			
		Green		565			
λ_d	Dominant Wavelength	High Efficiency Red		626		nm	See Note 2
		Yellow		585			
		Green		569			
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth	High Efficiency Red		40		nm	
		Yellow		36			
		Green		28			
τ_S	Speed of Response	High Efficiency Red		90		ns	
		Yellow		90			
		Green		500			
C	Capacitance	High Efficiency Red		11		pF	V_F = 0; f = 1 MHz
		Yellow		15			
		Green		18			
θ_{JC}	Thermal Resistance	All		120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	High Efficiency Red	1.5	2.2	3.0	V	I_F = 10 mA (Figures 2, 7, 12)
		Yellow	1.5	2.2	3.0		
		Green	1.5	2.3	3.0		
V_R	Reverse Breakdown Voltage	All	5.0			V	I_R = 100 μA
η_V	Luminous Efficacy	High Efficiency Red		145		lumens/Watt	See Note 3
		Yellow		500			
		Green		595			

Notes:
1. $\Theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$. Where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	High Eff. Red HLMP-6305	Yellow HLMP-6405	Green HLMP-6505	Units
Power Dissipation	135	85	135	mW
DC Forward Current	30[2]	20[1]	30[2]	mA
Peak Forward Current	90 See Fig. 5	60 See Fig. 10	90 See Fig. 15	mA
Reverse Voltage (I_R = 100 μA)	5	5	5	V
Transient Forward Current[3] (10 μsec Pulse)	500	500	500	mA
Operating Temperature Range	-55 to +100	-55 to +100	-20 to +100	°C
Storage Temperature Range			-55 to +100	
Lead Soldering Temperature [1.6 mm (0.063 in.) from body]	260° C for 3 seconds			

Notes:
1. Derate from 50° C at 0.2 mA/° C.
2. Derate from 50° C at 0.5 mA/° C.
3. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak current beyond the peak forward current listed in the Absolute Maximum Ratings.

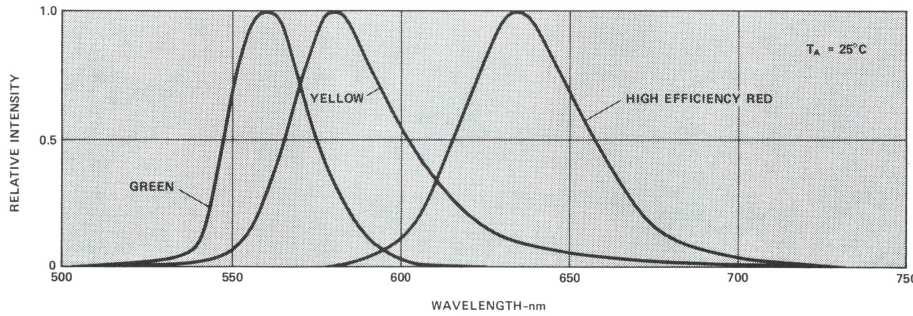


Figure 1. Relative Intensity vs. Wavelength

High Efficiency Red HLMP-6305

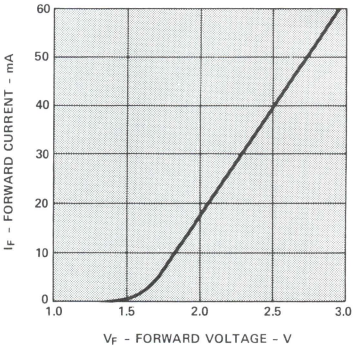


Figure 2. Forward Current vs. Forward Voltage Characteristics

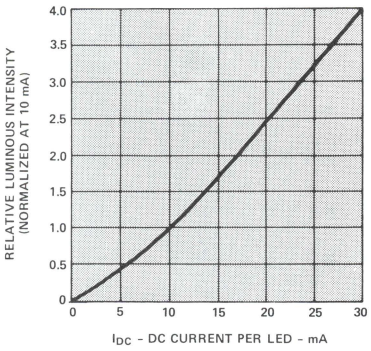


Figure 3. Relative Luminous Intensity vs. Forward Current

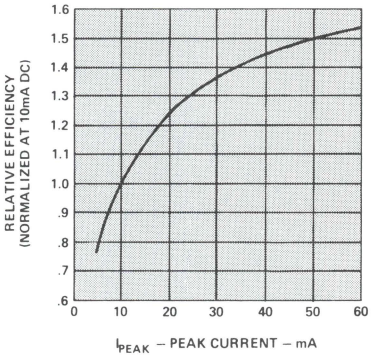


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current

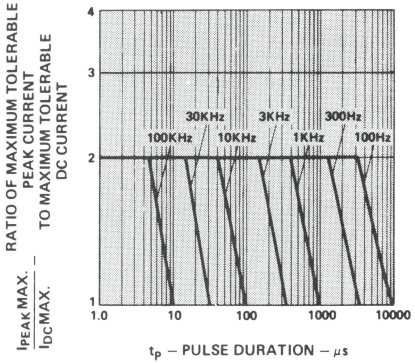


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration (I_{DC}MAX as per MAX Ratings)

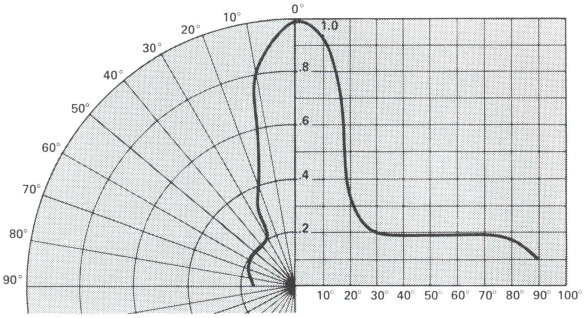


Figure 6. Relative Luminous Intensity vs. Angular Displacement

Yellow HLMP-6405

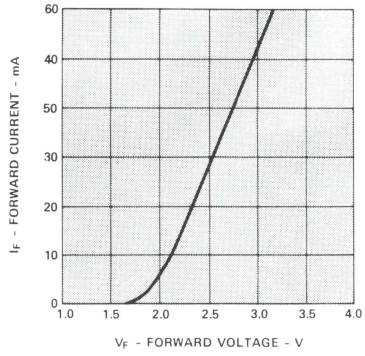


Figure 7. Forward Current vs. Forward Voltage Characteristics

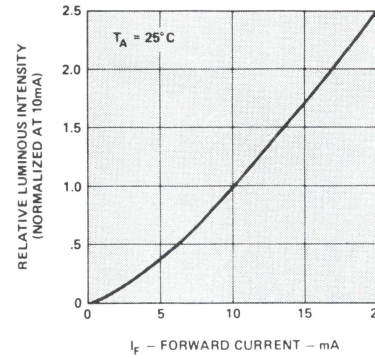


Figure 8. Relative Luminous Intensity vs. Forward Current

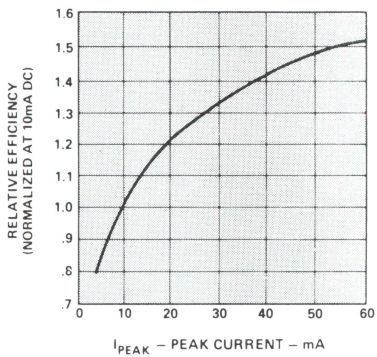


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current

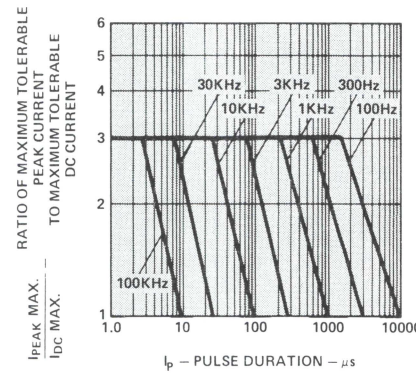


Figure 10. Maximum Tolerable Peak Current vs. Pulse Duration (I_{DC} MAX as per MAX Ratings)

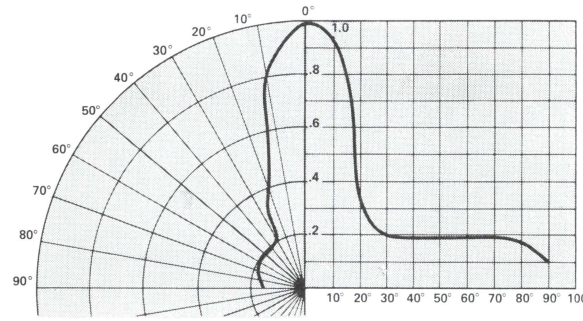


Figure 11. Relative Luminous Intensity vs. Angular Displacement

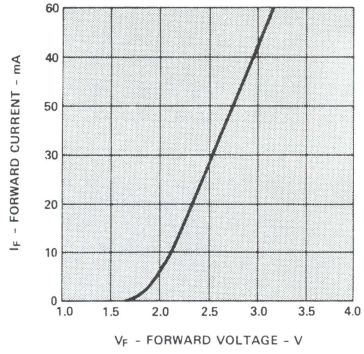


Figure 12. Forward Current vs. Forward Voltage Characteristics

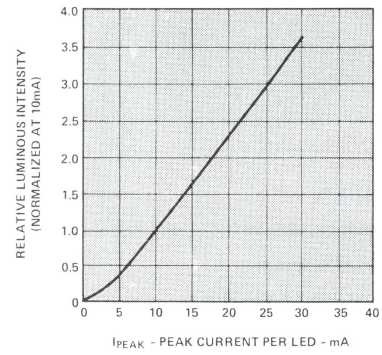


Figure 13. Relative Luminous Intensity vs. Forward Current

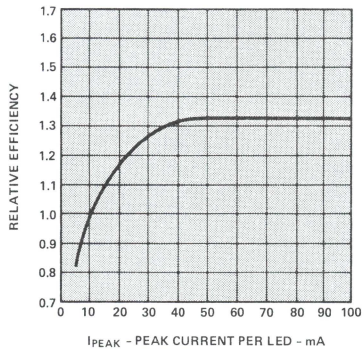


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current

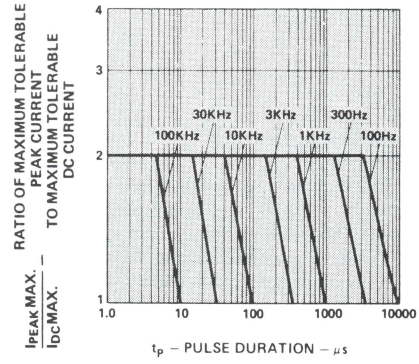


Figure 15. Maximum Tolerable Peak Current vs. Pulse Duration (I_{DC} MAX as per MAX Ratings)

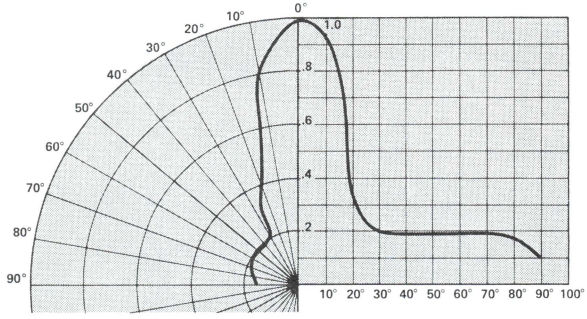


Figure 16. Relative Luminous Intensity vs. Angular Displacement

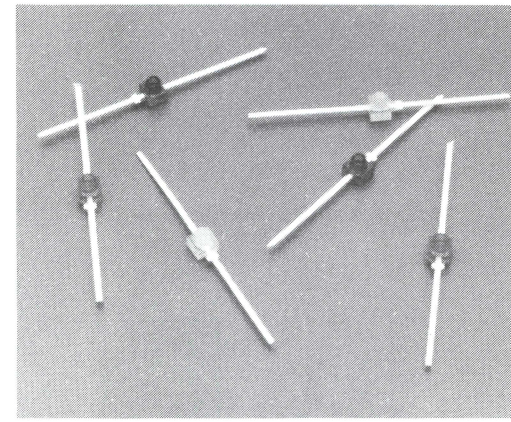
HEWLETT PACKARD

SUBMINIATURE SOLID STATE LAMPS

RED • HLMP-6000/6001
HIGH EFFICIENCY RED • HLMP-6300
ORANGE • HLMP-Q400
YELLOW • HLMP-6400
HIGH PERFORMANCE GREEN • HLMP-6500

Features

- **SUBMINIATURE PACKAGE STYLE**
- **END STACKABLE**
- **LOW PACKAGE PROFILE**
- **AXIAL LEADS**
- **WIDE VIEWING ANGLE**
- **LONG LIFE — SOLID STATE RELIABILITY**
- **AVAILABLE IN BULK, ARRAYS, TAPE AND REEL, SURFACE MOUNT, AND BENT LEAD CONFIGURATIONS**



Description

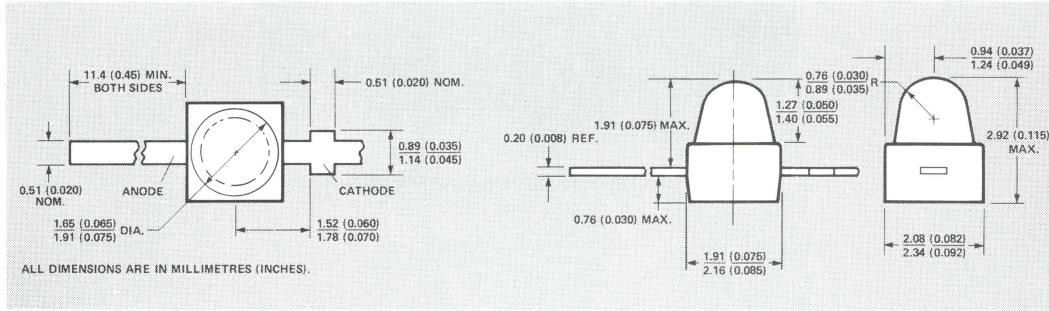
Lamps in this series of solid state indicators are encapsulated in an axial lead subminiature package of molded epoxy. They utilize a tinted, diffused lens providing high on-off contrast and wide angle viewing. Small size makes these lamps suitable for PC board mounting in space sensitive applications.

Special lead bending, packaging and assembly methods can be used with these devices. For example, lead bending on 2.54 mm (0.100 in) and 5.08 mm (0.200 in) centers is available. Two special surface mount lead configurations are also available. See the data sheets for "gull wing," "yoke lead" and bend options for more detailed information.

Tape and reel packaging for the standard product and for the surface mountable "gull wing" and "yoke lead" versions is described in their respective surface mount data sheets.

Part Number HLMP-	Minimum Intensity (mcd) at 10 mA	Color (Material)
6000	0.5	Standard Red (GaAsP)
6001	1.3	Standard Red (GaAsP)
6300	1.0	High Efficiency Red (GaP on GaAsP)
Q400	1.0	Orange (GaP on GaAsP)
6400	1.0	Yellow (GaP on GaAsP)
6500	1.0	Green (GaP)

Package Dimensions



Electrical Characteristics at $T_A = 25°C$

Symbol	Parameter	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	Standard Red 6000 6001	 0.5 1.3	 1.2 3.2			
		High Efficiency Red 6300	 1.0	 3.0			
		Orange Q400	 1.0	 3.0		mcd	I_F = 10 mA (Figures 3, 8, 13, 18)
		Yellow 6400	 1.0	 3.0			
		Green 6500	 1.0	 3.0			
$2\Theta_{1/2}$	Including Angle Between Half Luminous Intensity Points	All		90		Deg.	See Note 1 (Figures 6, 11, 16, 21)
λ_{PEAK}	Peak Wavelength	Standard Red High Efficiency Red Orange Yellow Green		655 635 612 583 565		nm	Measurement at Peak
λ_d	Dominant Wavelength	Standard Red High Efficiency Red Orange Yellow Green		640 626 603 585 569		nm	See Note 2
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth	Standard Red High Eff. Red/Orange Yellow Green		24 40 36 28		nm	
τ_S	Speed of Response	Standard Red High Efficiency Red Orange Yellow Green		15 90 260 90 500		ns	
C	Capacitance	Standard Red High Efficiency Red Orange Yellow Green		100 11 4 15 18		pF	V_F = 0; f = 1 MHz
θ_{JC}	Thermal Resistance	All		120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	Standard Red High Efficiency Red Orange Yellow Green	1.4 1.5 1.5 1.5 1.5	1.6 2.2 2.2 2.2 2.3	2.0 3.0 3.0 3.0 3.0	V	I_F = 10 mA (Figures 2, 7, 12, 17)
V_R	Reverse Breakdown Voltage	All	5.0			V	I_R = 100 μA
η_V	Luminous Efficacy	Standard Red High Efficiency Red Orange Yellow Green		65 145 262 500 595		$\frac{\text{lumens}}{\text{Watt}}$	See Note 3

Notes on following page.

Notes:
1. $\Theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_v/\eta_v$. Where I_v is the luminous intensity in candelas and η_v is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	Red HLMP-6000/1	High Eff. Red HLMP-6300	Orange HLMP-Q400	Yellow HLMP-6400	Green HLMP-6500	Units
Power Dissipation	100	135	135	85	135	mW
DC Forward Current	50[1]	30[2]	30[2]	20[1]	30[2]	mA
Peak Forward Current	1000 See Fig. 5	90 See Fig. 10	90 See Fig. 10	60 See Fig. 15	90 See Fig. 20	mA
Reverse Voltage (I_R = 100 μA)	5	5	5	5	5	V
Transient Forward Current[2] (10 μsec Pulse)	2000	500	500	500	500	mA
Operating Temperature Range	-55 to +100	-55 to +100	-55 to +100	-55 to +100	-20 to +100	°C
Storage Temperature Range					-55 to +100	
Lead Soldering Temperature [1.6 mm (0.063 in.) from body]	260° C for 3 seconds					

Notes:
1. Derate from 50° C at 0.2 mA/° C.
2. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak current beyond the peak forward current listed in the Absolute Maximum Ratings.

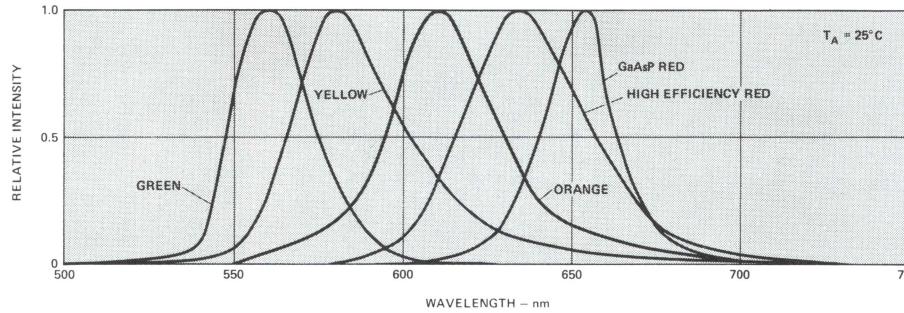


Figure 1. Relative Intensity vs. Wavelength

Standard Red HLMP-6000/6001

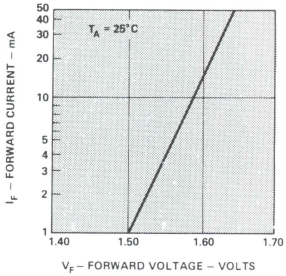


Figure 2. Forward Current vs. Forward Voltage.

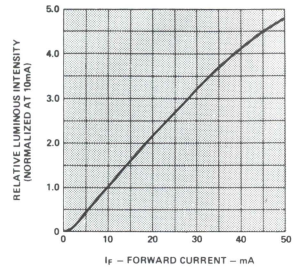


Figure 3. Relative Luminous Intensity vs. Forward Current.

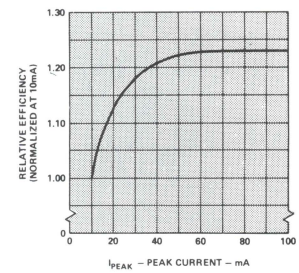


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

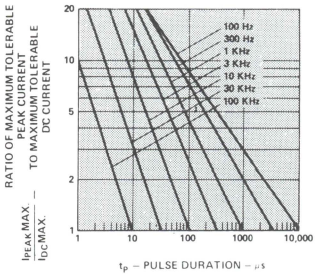


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

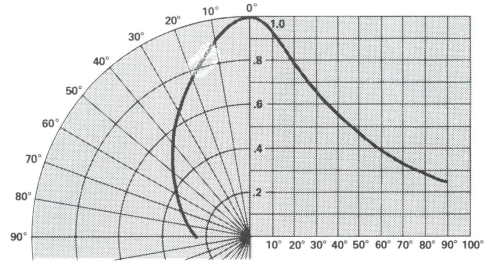


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

High Efficiency Red HLMP-6300, Orange HLMP-Q400

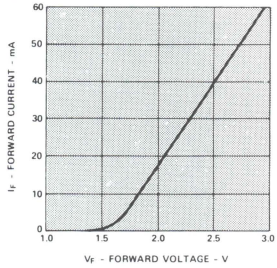


Figure 7. Forward Current vs. Forward Voltage Characteristics

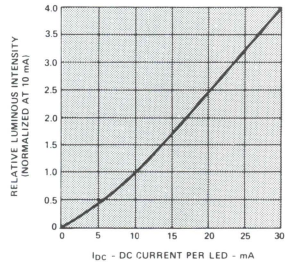


Figure 8. Relative Luminous Intensity vs. Forward Current.

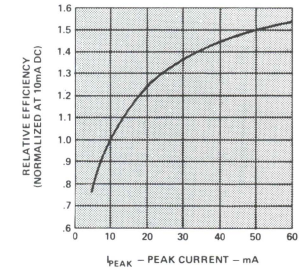


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

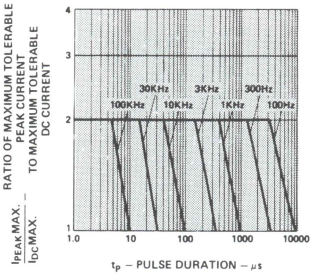


Figure 10. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

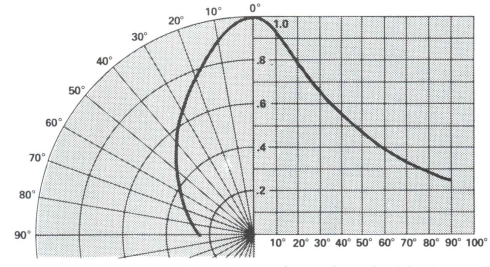


Figure 11. Relative Luminous Intensity vs. Angular Displacement.

Yellow HLMP-6400

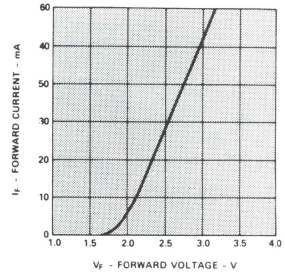


Figure 12. Forward Current vs. Forward Voltage Characteristics

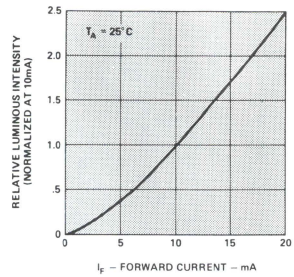


Figure 13. Relative Luminous Intensity vs. Forward Current.

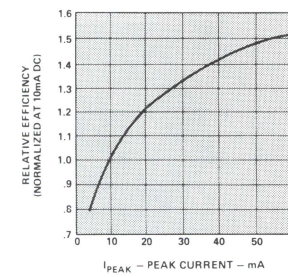


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

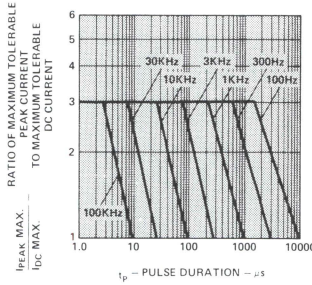


Figure 15. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

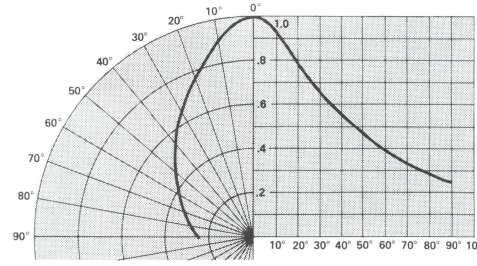


Figure 16. Relative Luminous Intensity vs. Angular Displacement.

Green HLMP-6500

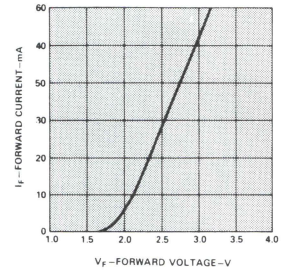


Figure 17. Forward Current vs. Forward Voltage.

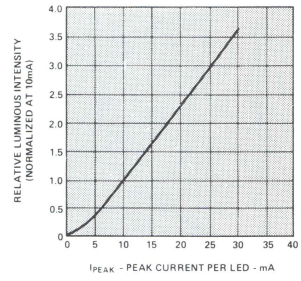


Figure 18. Relative Luminous Intensity vs. DC Forward Current

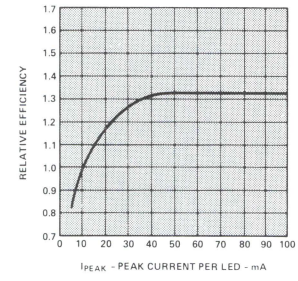


Figure 19. Relatiave Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

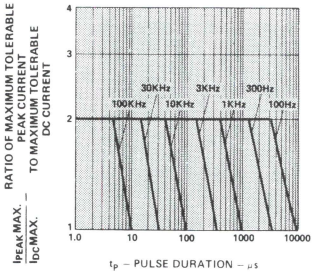


Figure 20. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

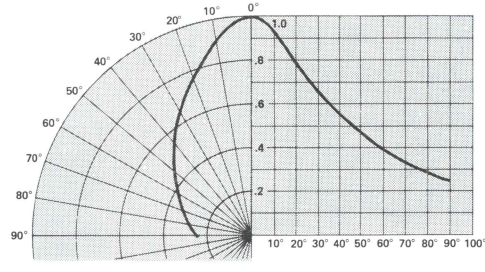


Figure 21. Relative Luminous Intensity vs. Angular Displacement.

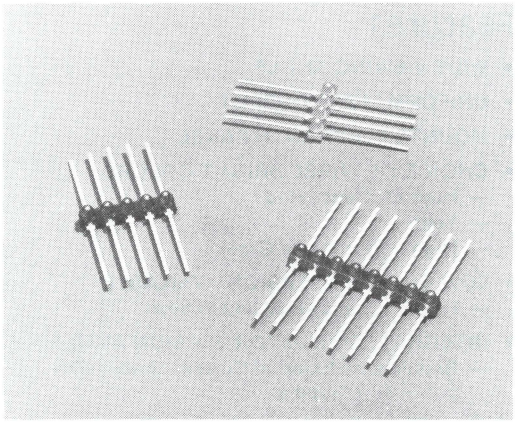
HEWLETT PACKARD

MATCHED ARRAYS OF SUBMINIATURE LAMPS

RED HLMP-6200 SERIES
HIGH EFFICIENCY RED HLMP-6650 SERIES
YELLOW HLMP-6750 SERIES
GREEN HLMP-6850 SERIES

Features

- **IMPROVED BRIGHTNESS**
- **AVAILABLE IN 4 BRIGHT COLORS**
  Red
  High Efficiency Red
  Yellow
  High Performance Green
- **EXCELLENT UNIFORMITY BETWEEN ELEMENTS**
- **END STACKABLE FOR LONGER ARRAYS**
- **SELECTION OF VARIOUS LENGTHS**
- **COMPACT SUBMINIATURE PACKAGE STYLE**
- **NO CROSSTALK BETWEEN ELEMENTS**



Description

The HLMP-6XXX Series Arrays are comprised of several subminiature lamps molded as a single bar. Arrays are tested to assure 2.1 to 1 matching between elements and intensity binned for matching between arrays.

The HLMP-620X Series Arrays are Gallium Arsenide Phosphide red light emitting diodes. The HLMP-665X, HLMP-675X series arrays are Gallium Arsenide Phosphide on Gallium Phosphide red and yellow light emitting diodes. The HLMP-685X series arrays are Gallium Phosphide green light emitting diodes.

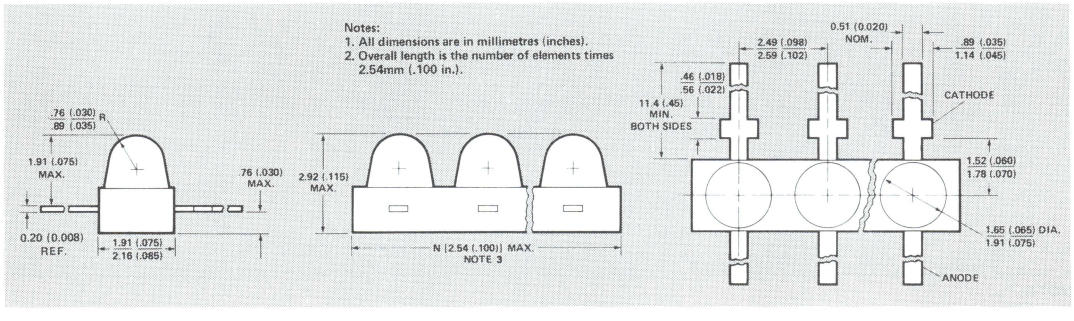
Each element has separately accessible leads and a diffused lens which provides a wide viewing angle and a high on/off contrast ratio. The center-to-center spacing is 2.54 mm (.100 in.) between elements. Special lead bending is available on 2.54 mm (.100 in.) and 5.08 mm (.200 in.) centers.

Applications

- **INDUSTRIAL CONTROLS**
- **POSITION INDICATORS**
- **OFFICE EQUIPMENT**
- **INSTRUMENTATION LOGIC INDICATORS**
- **CONSUMER PRODUCTS**

Array Length	Red	High Efficiency Red	Yellow	High Performance Green
3-Element HLMP-	6203	6653	6753	6853
4-Element HLMP-	6204	6654	6754	6854
5-Element HLMP-	6205	6655	6755	6855
6-Element HLMP-	6206	6656	6756	6856
8-Element HLMP-	6208	6658	6758	6858

Package Dimensions



SOLID STATE LAMPS

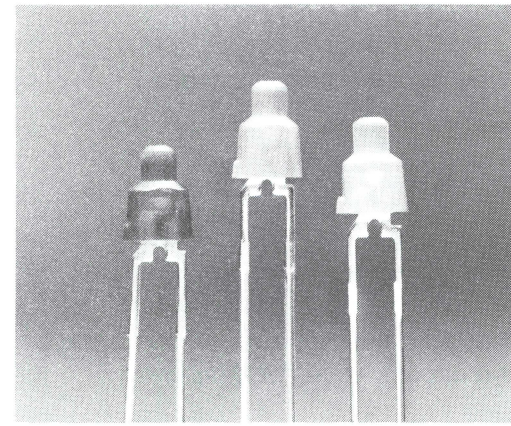
HEWLETT PACKARD

2mm FLAT TOP LED LAMPS

High Efficiency Red, Yellow, Green Lamps
Low Current Lamps
Integrated Resistor Lamps

Features

- WIDE VIEWING ANGLE
- UNIFORM LIGHT OUTPUT
- MOUNTS FLUSH WITH PANEL
- CHOICE OF THREE BRIGHT COLORS
  - — High Efficiency Red
  - — Yellow
  - — High Performance Green
- LOW CURRENT VERSION AVAILABLE
  - — High Efficiency Red and Yellow
- INTEGRATED RESISTOR VERSION AVAILABLE
  - — Requires no External Current Limiter with 5 V — 12 V Supply



Description

These rugged solid state lamps are designed for applications requiring a bright, compact source of light. Uniform light output, wide viewing angle and flat top make the lamp ideal for flush mounting on a front panel.

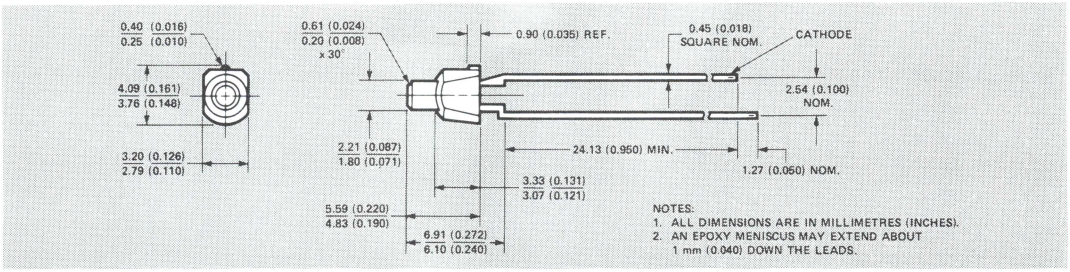
The red and yellow devices use Gallium Arsenide Phosphide on Gallium Phosphide light emitting diodes, the green devices use a Gallium Phosphide light emitting diode.

Axial Luminous Intensity and Viewing Angle

Color	Part Number HLMP-	Description	I_V (mcd)		Test Condition	$2\Theta 1/2$[1]
			Min.	Typ.		
High Efficiency Red	-1800	Tinted, Diffused	0.8	1.8	10 mA	140
	-1801	Tinted, Diffused, High Brightness	2.1	2.9	10 mA	
	-1740	Tinted, Diffused, Low Current	0.2	0.5	2 mA	
	-1660	Tinted, Diffused, 5 V Integrated Resistor	0.5		5 V	
	-1661	Tinted, Diffused, 12 V Integrated Resistor	0.8		12 V	
Yellow	-1819	Tinted, Diffused	0.9	1.5	10 mA	140
	-1820	Tinted, Diffused, High Brightness	1.4	2.5	10 mA	
	-1760	Tinted, Diffused, Low Current	0.2	0.4	2 mA	
	-1674	Tinted, Diffused, 5 V Integrated Resistor	0.5		5 V	
	-1675	Tinted, Diffused, 12 V Integrated Resistor	0.9		12 V	
Green	-1840	Tinted, Diffused	1.0	2.0	10 mA	140
	-1841	Tinted, Diffused, High Brightness	1.6	3.0	10 mA	
	-1687	Tinted, Diffused, 5 V Integrated Resistor	0.5		5 V	
	-1688	Tinted, Diffused, 12 V Integrated Resistor	1.0		12 V	

NOTE:
1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial intensity.

Package Dimensions



Absolute Maximum Ratings at $T_A = 25°C$

HIGH EFFICIENCY RED, YELLOW AND GREEN LAMPS

Parameter	High Efficiency Red HLMP-1800/-1801	Yellow HLMP-1819/-1820	Green HLMP-1840/-1841	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Reverse Voltage (I_R = 100 μA)	5	5	5	V
Transient Forward Current[4] (10 μsec Pulse)	500	500	500	mA
Operating Temperature Range	−55 to +100		−20 to +100	°C
Storage Temperature Range			−55 to +100	
Lead Soldering Temperature (1.6 mm [0.063 in.] from body)	260° C for 5 seconds			

NOTES:
1. See Figure 3 to establish pulsed operating conditions.
2. For Red and Green Series derate linearly from 50° C at 0.5 mA/° C. For Yellow Series derate linearly from 50° C at 0.2 mA/° C.
3. For Red and Green Series derate power linearly from 25° C at 1.8 mW/° C. For Yellow Series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

LOW CURRENT LAMPS

Parameter	High Efficiency Red HLMP-1740	Yellow HLMP-1760	Units
DC and Peak Forward Current[1]	7	7	mA
Transient Forward Current (10 msec Pulse)	500	500	mA
Power Dissipation	27	24	mW
Reverse Voltage (I_R = 50 μA)	5.0		V
Operating and Storage Temperature Range	−55 to +100		°C
Lead Soldering Temperature (1.6 mm [0.063 in.] from body)	260° C for 5 seconds		

NOTES:
1. Derate linearly from 92° C at 1.0 mA/° C.

INTEGRATED RESISTOR LAMPS

Parameter	5 V Lamps HER/Yellow HLMP-1660 HLMP-1674	12 V Lamps HER/Yellow HLMP-1661 HLMP-1675	5 V Lamps Green HLMP-1687	12 V Lamps Green HLMP-1688
Reverse Voltage (I_R = 100 μA)	5 V	5 V	5 V	5 V
DC Forward Voltage (T_A = 25° C)	7.5 V[1]	15 V[2]	7.5 V[1]	15 V[2]
Operating Temperature Range	−40° C to 85° C	−40° C to 85° C	−20° C to 85° C	−20° C to 85° C
Storage Temperature Range	−55° C to 100° C	−55° C to 100° C	−55° C to 100° C	−55° C to 100° C
Lead Soldering Temperature	260° C for 5 seconds			

NOTES:
1. Derate from T_A = 50° C at 0.071 V/° C, see Figure 3.
2. Derate from T_A = 50° C at 0.086 V/° C, see Figure 4.

Electrical/Optical Characteristics at $T_A = 25°C$

		High Efficiency Red			Yellow			Green				
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
λ_{PEAK}	Peak Wavelength		635			583			565		nm	
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth		40			36			28		nm	
λ_d	Dominant Wavelength		626			585			569		nm	Note 1
η_V	Luminous Efficacy		145			500			595		lumen/watt	Note 2
V_R	Reverse Breakdown Voltage	5.0			5.0			5.0			V	$I_R = 100\ \mu A$

NOTES:
1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
2. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$. Where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

HIGH EFFICIENCY RED, YELLOW AND GREEN LAMPS

		High Efficiency Red HLMP-1800/-1801			Yellow HLMP-1819/-1820			Green HLMP-1840/-1841				
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
V_F	Forward Voltage	1.5	2.2	3.0	1.5	2.2	3.0	1.5	2.3	3.0	V	$I_F = 10$ mA
τ_S	Speed of Response		90			90			500		ns	
C	Capacitance		20			15			18		pF	$V_F = 0$, f = 1 MHz
θ_{JC}	Thermal Resistance		120			120			120		°C/W	Junction to Cathode Lead

LOW CURRENT LAMPS

		High Efficiency Red HLMP-1740			Yellow HLMP-1760				
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
V_F	Forward Voltage		1.8	2.2		1.9	2.7	V	2 mA
τ_S	Speed of Response		90			90		ns	
C	Capacitance		11			15		pF	$V_F = 0$, f = 1 MHz
θ_{JC}	Thermal Resistance		120			120		°C/W	Junction to Cathode Lead

INTEGRATED RESISTOR LAMPS

		5 V HLMP-1660/ -1674/-1687			12 V HLMP-1661/ 1675/-1688				
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
I_F	Forward Current		10	15		13	20	mA	At rated voltage
θ_{JC}	Thermal Resistance		90			90		°C/W	Junction to Cathode Lead

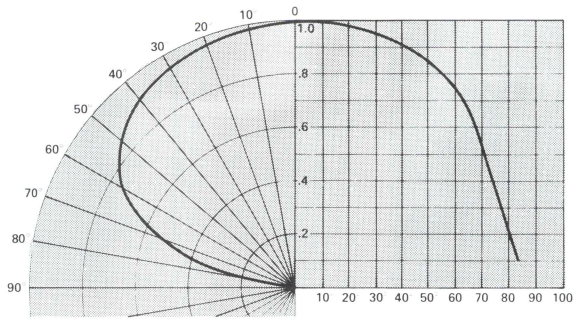


Figure 1. Relative Luminous Intensity vs. Angular Displacement

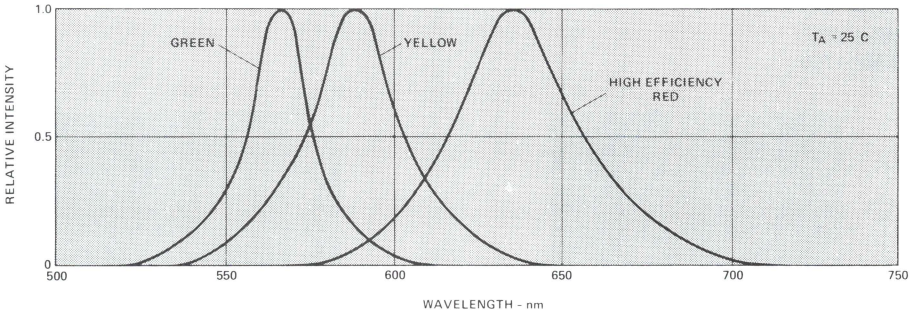


Figure 2. Relative Intensity vs. Wavelength

HIGH EFFICIENCY RED, YELLOW AND GREEN LAMPS

HER HLMP-1800,-1801
Yellow HLMP-1819,-1820
Green HLMP-1840,-1841

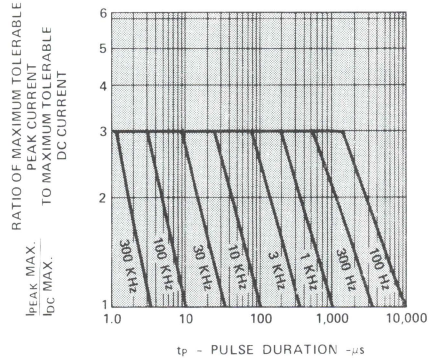


Figure 3. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings.)

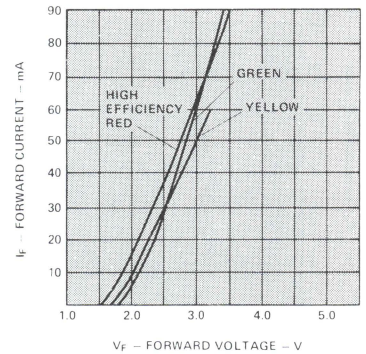


Figure 4. Forward Current vs. Forward Voltage

SOLID STATE LAMPS

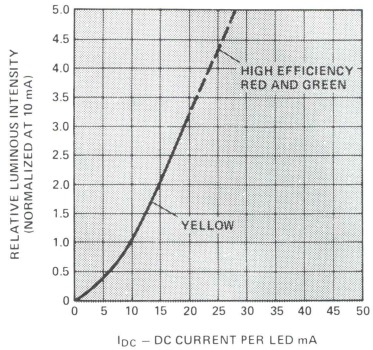


Figure 5. Relative Luminous Intensity vs. Forward Current

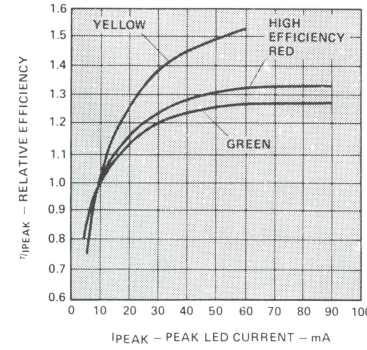


Figure 6. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

LOW CURRENT LAMPS

HER HLMP-1740
Yellow HLMP-1760

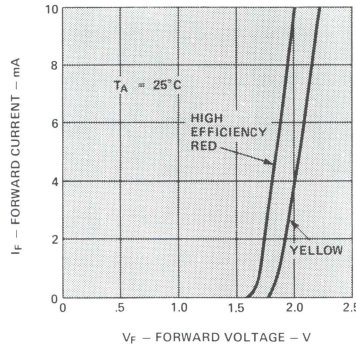


Figure 7. Forward Current vs. Forward Voltage

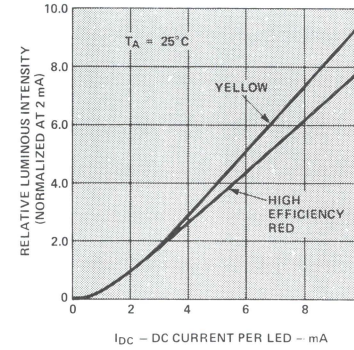


Figure 8. Relative Luminous Intensity vs. Forward Current

INTEGRATED RESISTOR LAMPS

5 Volt HLMP-1660, -1674, 1687
12 Volt HLMP-1661, -1675, -1688

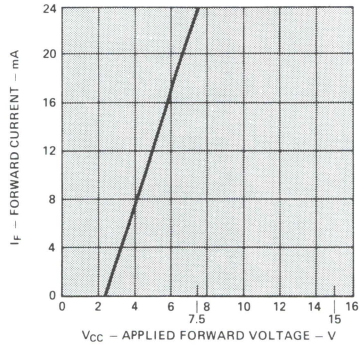


Figure 9. Forward Current vs. Applied Forward Voltage. 5 Volt Devices

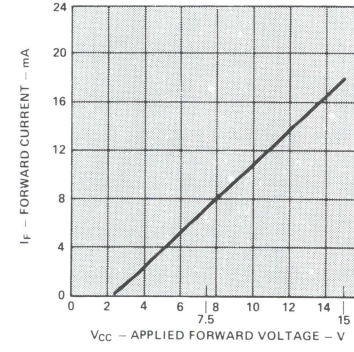


Figure 10. Forward Current vs. Applied Forward Voltage. 12 Volt Devices

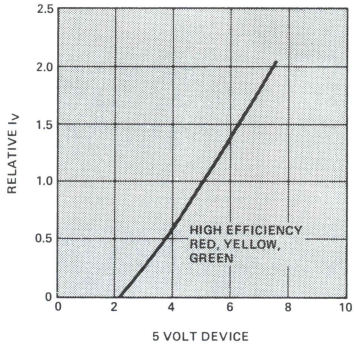


Figure 11. Relative Luminous Intensity vs. Applied Forward Voltage. 5 Volt Devices

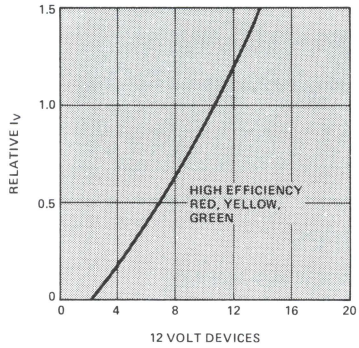


Figure 12. Relative Luminous Intensity vs. Applied Forward Voltage. 12 Volt Devices

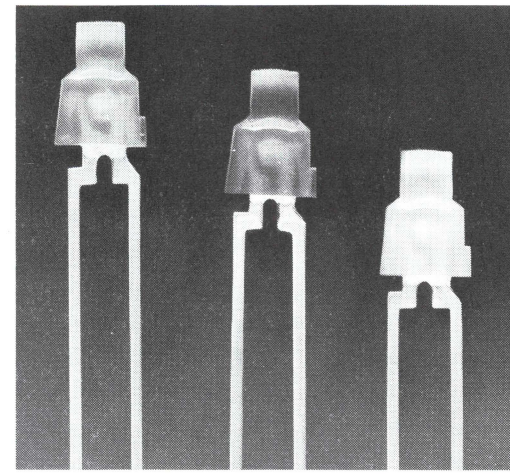
HEWLETT PACKARD

2mm SQUARE FLAT TOP LED LAMPS

High Efficiency Red HLMP-L250, -L251
Yellow HLMP-L350, -L351
Green HLMP-L550, -L551

Features

- WIDE VIEWING ANGLE
- UNIFORM LIGHT OUTPUT
- SQUARE LIGHT EMITTING AREA
- MOUNTS FLUSH WITH PANEL
- CHOICE OF THREE BRIGHT COLORS
  - — High Efficiency Red
  - — Yellow
  - — High Performance Green



Description

These rugged solid state lamps are designed for applications requiring a bright, compact source of light. Uniform light output, wide viewing angle and flat top make the lamp ideal for flush mounting on a front panel.

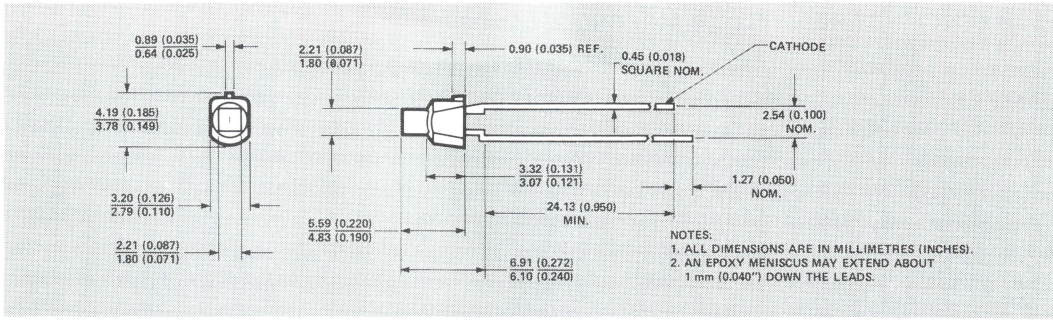
The red and yellow devices use Gallium Arsenide Phosphide on Gallium Phosphide light emitting diodes, the green devices use a Gallium Phosphide light emitting diode.

Axial Luminous Intensity and Viewing Angle

Color	Part Number HLMP-	Description	I_V (mcd) Min.	I_V (mcd) Typ.	Test Condition	$2\Theta 1/2$[1]
High Efficiency Red	-L250	Tinted, Diffused	0.8	1.8	10 mA	140
	-L251	Tinted, Diffused, High Brightness	2.1	2.9	10 mA	
Yellow	-L350	Tinted, Diffused	0.9	1.5	10 mA	140
	-L351	Tinted, Diffused, High Brightness	1.4	2.5	10 mA	
Green	-L550	Tinted, Diffused	1.0	2.0	10 mA	140
	-L551	Tinted, Diffused, High Brightness	1.6	3.0	10 mA	

NOTE:
1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial intensity.

Package Dimensions



Electrical/Optical Characteristics at $T_A = 25°C$

COMMON CHARACTERISTICS

		High Efficiency Red L250//L251			Yellow L350/351			Green L550/551				
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
λ_{PEAK}	Peak Wavelength		635			583			565		nm	
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth		40			36			28		nm	
λ_d	Dominant Wavelength		626			585			569		nm	Note 1
η_V	Luminous Efficacy		145			500			595		lumen/watt	Note 2
V_R	Reverse Breakdown Voltage	5.0			5.0			5.0			V	I_R = 100 μA
V_F	Forward Voltage	1.5	2.2	3.0	1.5	2.2	3.0	1.5	2.3	3.0	V	I_F = 10 mA
τ_S	Speed of Response		90			90			500		ns	
C	Capacitance		11			15			18		pF	V_F = 0, f = 1 MHz
θ_{JC}	Thermal Resistance		120			120			120		°C/W	Junction to Cathode Lead

NOTES:

1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavlength which defines the color of the device.
2. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$. Where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

HIGH EFFICIENCY RED, YELLOW AND GREEN LAMPS

Parameter	High Efficiency Red HLMP-L250/-L251	Yellow HLMP-L350/-L351	Green HLMP-L550/-L551	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Reverse Voltage ($I_R = 100\ \mu A$)	5	5	5	V
Transient Forward Current[4] (10 μsec Pulse)	500	500	500	mA
Operating Temperature Range	−55 to +100		−20 to +100	°C
Storage Temperature Range			−55 to +100	
Lead Soldering Temperature (1.6 mm [0.063 in.] from body)	260° C for 5 seconds			

NOTES:

1. See Figure 3 to establish pulsed operating conditions.
2. For Red and Green Series derate linearly from 50° C at 0.5 mA/° C. For Yellow Series derate linearly from 50° C at 0.2 mA/° C.
3. For Red and Green Series derate power linearly from 25° C at 1.8 mW/° C. For Yellow Series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

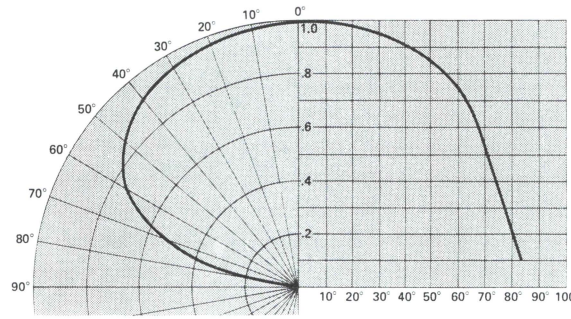


Figure 1. Relative Luminous Intensity vs. Angular Displacement

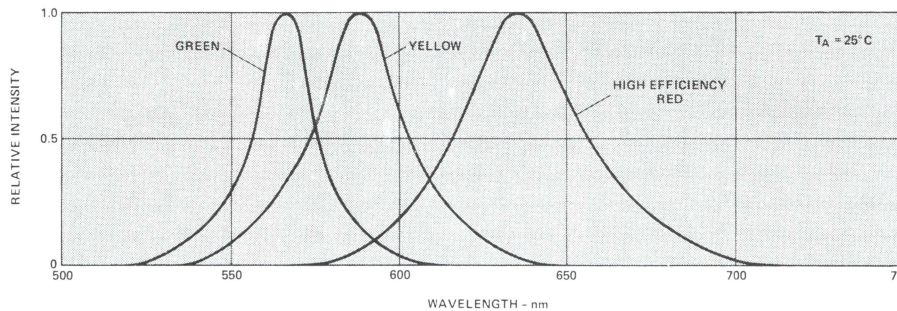


Figure 2. Relative Intensity vs. Wavelength

HIGH EFFICIENCY RED, YELLOW AND GREEN LAMPS

HER HLMP-L250, -L251
Yellow HLMP-L350, -L351
Green HLMP-L550, -L551

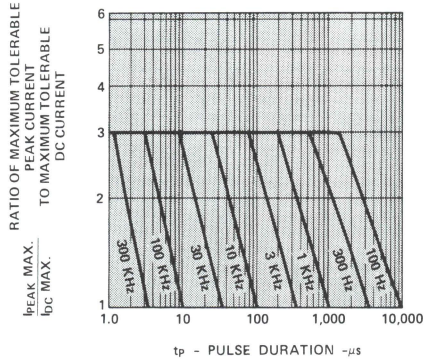


Figure 3. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings.)

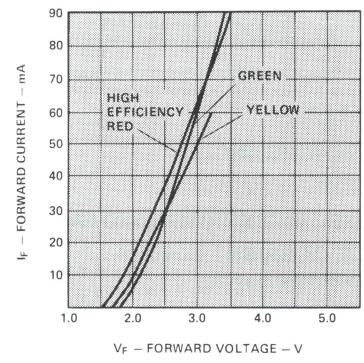


Figure 4. Forward Current vs. Forward Voltage

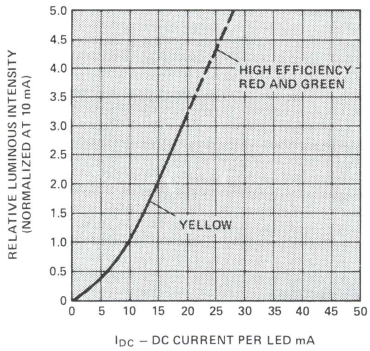


Figure 5. Relative Luminous Intensity vs. Forward Current

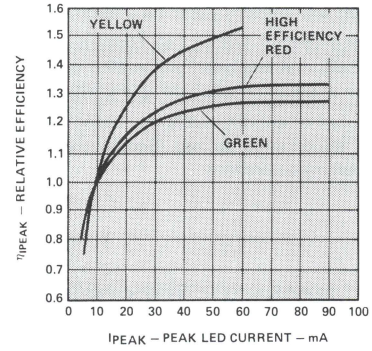


Figure 6. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

SOLID STATE LAMPS

HEWLETT PACKARD

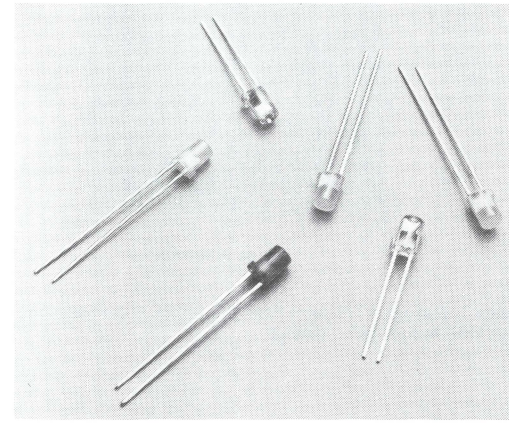
4mm FLAT TOP LED LAMPS

High Efficiency Red, Yellow, Green Lamps

HIGH EFFICIENCY RED HLMP-M200, -M201, -M250, -M251
YELLOW HLMP-M300, -M301, -M350, -M351
GREEN HLMP-M500, -M501, -M550, -M551

Features

- **WIDE VIEWING ANGLE**
- **FLAT TOP**
- **DIFFUSED AND NONDIFFUSED PACKAGES**
- **CHOICE OF BRIGHT COLORS**
  - **— High Efficiency Red**
  - **— Yellow**
  - **— High Performance Green**



Description

This line of solid state lamps is designed for applications requiring lamps with a pleasing, flat, light emitting surface in combination with a 4mm cylindrical shape.

The red and yellow devices use Gallium Arsenide Phosphide on Gallium Phosphide light emitting diodes, the green devices use a Gallium Phosphide light emitting diode.

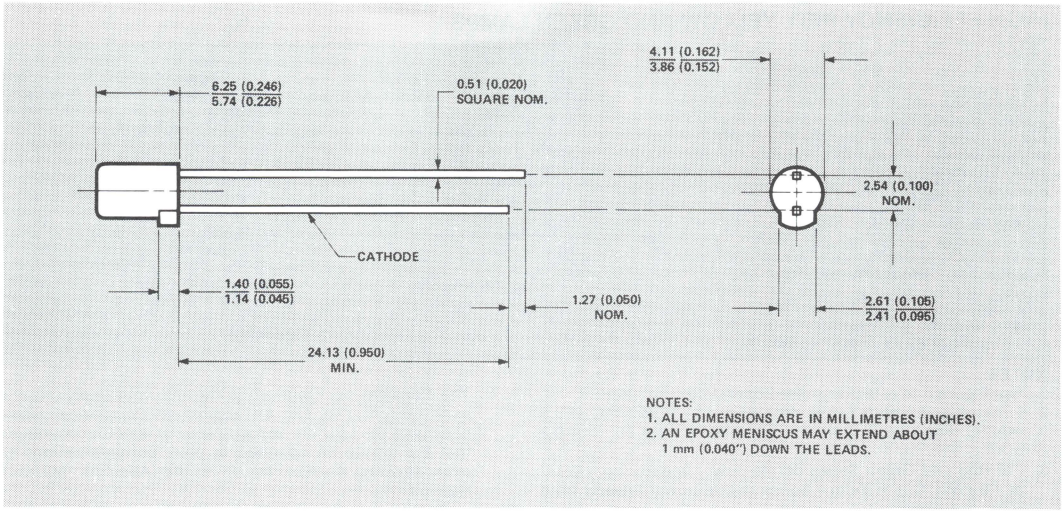
Select diffused or nondiffused lamps based on the radiation pattern or appearance desired. See Figure 1 for detailed radiation pattern differences.

Axial Luminous Intensity and Viewing Angle

Color (Material)	Part Number HLMP-	Description	I_V (mcd) Min.	I_V (mcd) Typ.	Test Condition (mA)	$2\Theta 1/2$[1]
High Efficiency Red (GaAsP on GaP)	M200	Tinted, Diffused	3.4	5.0	20	135
	M201	Tinted, Diffused, High Brightness	5.4	7.0	20	
	M250	Tinted, Nondiffused	3.4	5.0	10	80
	M251	Tinted, Nondiffused, High Brightness	5.4	7.0	10	
Yellow (GaAsP on GaP)	M300	Tinted, Diffused	3.6	5.0	20	135
	M301	Tinted, Diffused, High Brightness	5.7	7.0	20	
	M350	Tinted, Nondiffused	3.6	5.0	10	80
	M351	Tinted, Nondiffused, High Brightness	5.7	7.0	10	
Green (GaP)	M500	Tinted, Diffused	4.2	7.0	20	135
	M501	Tinted, Diffused, High Brightness	6.7	10.0	20	
	M550	Tinted, Nondiffused	4.2	10.0	10	80
	M551	Tinted, Nondiffused, High Brightness	6.7	16.0	10	

NOTE: 1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial intensity.

Package Dimensions



Electrical/Optical Characteristics at $T_A = 25°C$

COMMON CHARACTERISTICS

		High Efficiency Red HLMP-M2XX			Yellow HLMP-M3XX			Green HLMP—M5XX				
Symbol	**Parameter**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Units**	**Test Conditions**
λ_{PEAK}	Peak Wavelength		635			583			565		nm	
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth		40			36			28		nm	
λ_d	Dominant Wavelength		626			585			569		nm	Note 1
η_V	Luminous Efficacy		142			500			595		lumen /watt	Note 2
V_R	Reverse Breakdown Voltage	5.0			5.0			5.0			V	I_R = 100 μA
V_F	Forward Voltage	1.5	2.2	3.0	1.5	2.2	3.0	1.5	2.3	3.0	V	Clear I_F = 10 mA, Diffused I_F = 20 mA
τ_S	Speed of Response		90			90			500		ns	
C	Capacitance		11			15			18		pF	V_F = 0, f = 1 MHz
θ_{JC}	Thermal Resistance		120			120			120		°C/W	Junction to Cathode Lead

NOTES:

1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
2. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$. Where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

HIGH EFFICIENCY RED, YELLOW AND GREEN LAMPS

Parameter	High Efficiency Red HLMP-M2XX	Yellow HLMP-M3XX	Green HLMP-M5XX	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Reverse Voltage ($I_R = 100\ \mu A$)	5	5	5	V
Transient Forward Current[4] (10 μsec Pulse)	500	500	500	mA
Operating Temperature Range	−55 to +100		−20 to +100	°C
Storage Temperature Range			−55 to +100	
Lead Soldering Temperature (1.6 mm [0.063 in.] from body)	260° C for 5 seconds			

NOTES:

1. See Figure 3 to establish pulsed operating conditions.
2. For Red and Green Series derate linearly from 50° C at 0.5 mA/° C. For Yellow Series derate linearly from 50° C at 0.2 mA/° C.
3. For Red and Green Series derate power linearly from 25° C at 1.8 mW/° C. For Yellow Series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

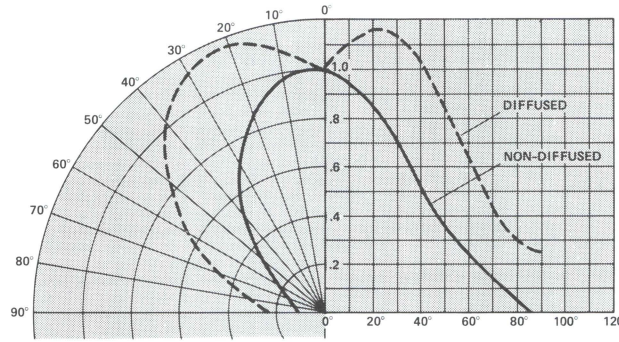


Figure 1. Relative Luminous Intensity vs. Angular Displacement

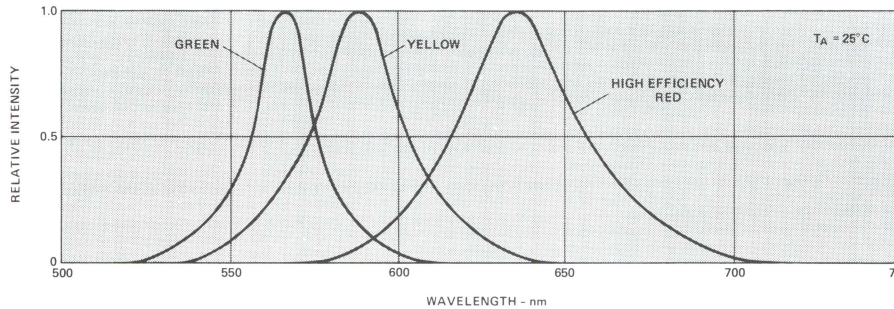


Figure 2. Relative Intensity vs. Wavelength

HIGH EFFICIENCY RED, YELLOW AND GREEN LAMPS

HER HLMP-M2XX Series
Yellow HLMP-M3XX Series
Green HLMP-M5XX Series

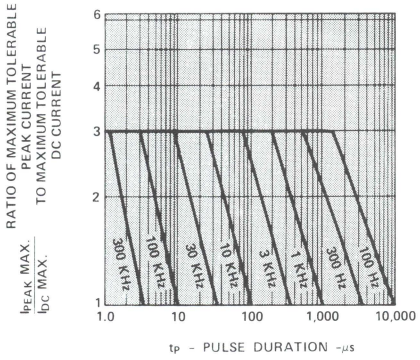


Figure 3. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings.)

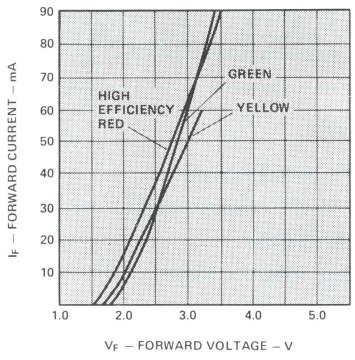


Figure 4. Forward Current vs. Forward Voltage

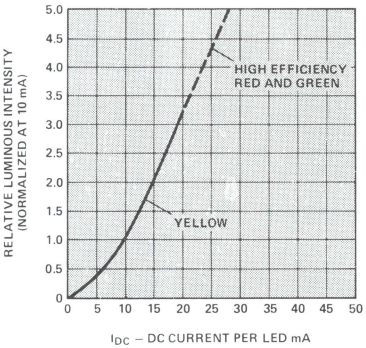


Figure 5. Relative Luminous Intensity vs. Forward Current. Nondiffused Devices.

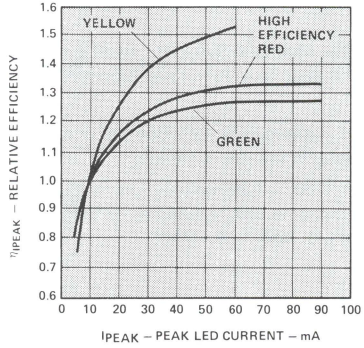


Figure 6. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current. Nondiffused Devices.

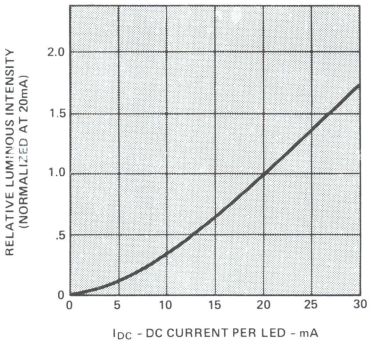


Figure 7. Relative Luminous Intensity vs. Forward Current. Diffused Devices.

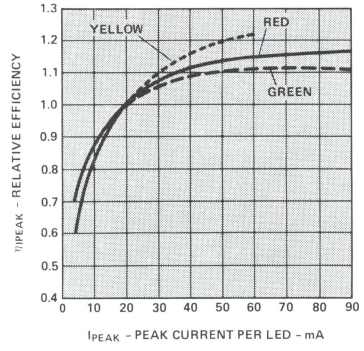


Figure 8. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current. Diffused Devices.

HEWLETT PACKARD

T-1 (3mm) RED SOLID STATE LAMPS

HLMP-1000 Series
HLMP-1200 Series

Features

- **WIDE VIEWING ANGLE**
- **SMALL SIZE T-1 DIAMETER 3.18mm (0.125")**
- **IC COMPATIBLE**
- **RELIABLE AND RUGGED**

Description

The HLMP-1000 is a series of Gallium Arsenide Phosphide Light Emitting Diodes designed for applications where space is at a premium, such as in high density arrays.

The HLMP-1000 series is available in three lens configurations.

HLMP-1000 — Red Diffused lens provides excellent on-off contrast ratio, high axial luminous intensity, and wide viewing angle.

HLMP-1080 — Same as HLMP-1000, but untinted diffused to mask red color in the "off" condition.

HLMP-1071/-1201 — Untinted non-diffused plastic lens provides a point source. Useful when illuminating external lens, annunciators, or photo-detectors.

Part Number HLMP-	Package & Lens Type	Iv (mcd) @ 20 mA		Typ. Viewing Angle 2Θ 1/2
		Min.	Typ.	
-1000	A-Tinted Diffused	.5	1.0	60°
-1002	A-Tinted Diffused	1.5	2.5	60°
-1080	A-Untinted Diffused	.5	1.5	60°
-1071	A-Untinted Non-Diffused	1.0	2.0	45°
-1200	B-Untinted Non-Diffused	.5	1.0	120°
-1201	B-Untinted Non-Diffused	1.5	2.5	120°

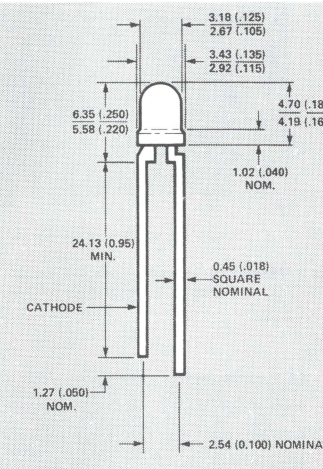


Figure A.

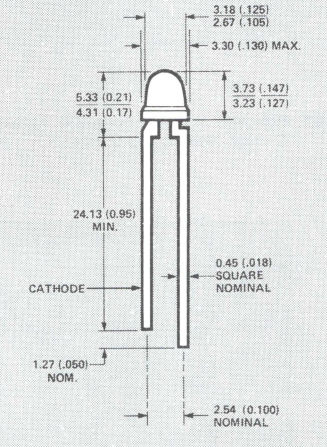


Figure B.

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1mm (.040") DOWN THE LEADS.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	1000 Series	Units
Power Dissipation	100	mW
DC Forward Current [1]	50	mA
Average Forward Current	50	mA
Peak Operating Forward Current	1000	mA
Reverse Voltage (I_R = 100 μA)	5	V
Transient Forward Current[1] (10 μsec Pulse)	2000	mA
Operating and Storage Temperature Range	-55° C to +100° C	
Lead Solder Temperature (1.6 mm [0.063 inch] below package base)	260° C for 5 seconds	

Note:
1. Derate linearly from 50° C at 0.2 mA/° C.

Electrical Characteristics at T_A=25°C

Symbol	Parameters	Min.	Typ.	Max.	Units	Test Conditions
λ_{PEAK}	Peak Wavelength		655		nm	Measurement at Peak
λ_d	Dominant Wavelength		648		nm	
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth		24		nm	
τ_s	Speed of Response		10		ns	
C	Capacitance		100		pF	V_F = 0, f = 1 MHz
θ_{JC}	Thermal Resistance		120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	1.4	1.6	2.0	V	I_F = 20 mA
V_R	Reverse Breakdown Voltage	5			V	I_R = 100 μA

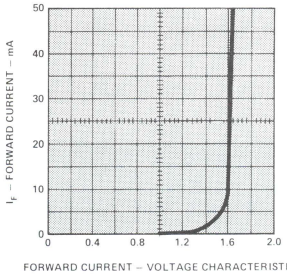


Figure 1. Forward Current vs. Voltage Characteristic.

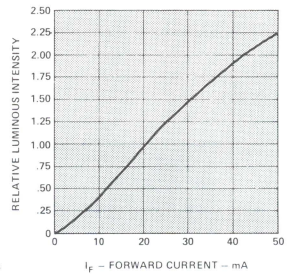


Figure 2. Luminous Intensity vs. Forward Current (IF).

HLMP-1200/-1201

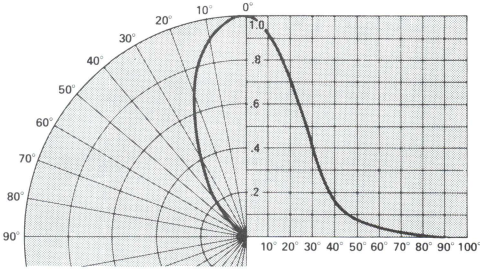


Figure 3. Typical Relative Luminous Intensity vs. Angular Displacement.

HLMP-1000/-1002/-1080

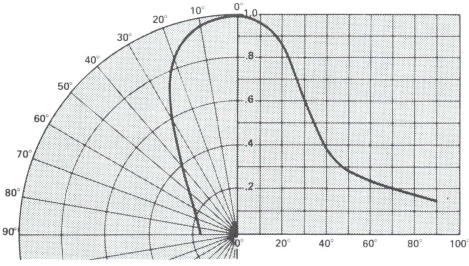


Figure 4. Relative Luminous Intensity vs. Angular Displacement.

HLMP-1071

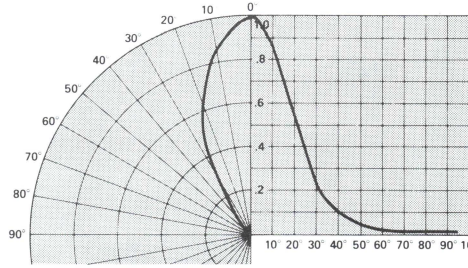


Figure 5. Relative Luminous Intensity vs. Angular Displacement.

SOLID STATE LAMPS

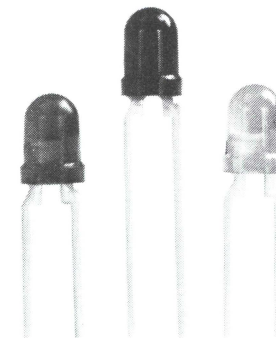
HEWLETT PACKARD

T-1 (3mm) DIFFUSED SOLID STATE LAMPS

HIGH EFFICIENCY RED ● HLMP-1300 SERIES
ORANGE ● HLMP-K400 SERIES
YELLOW ● HLMP-1400 SERIES
HIGH PERFORMANCE GREEN ● HLMP-1500 SERIES

Features

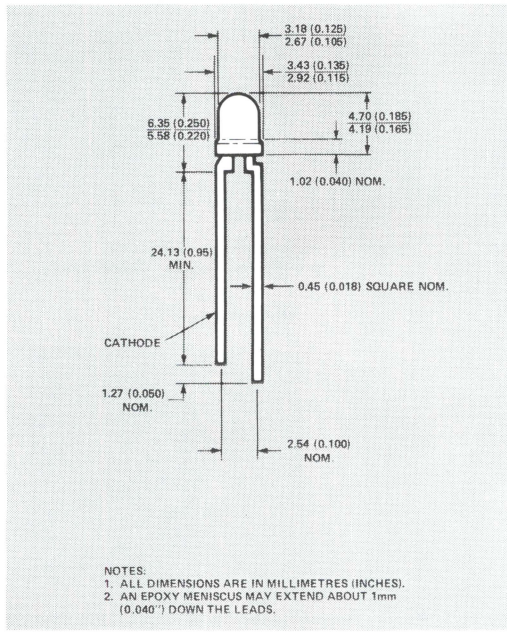
- HIGH INTENSITY
- CHOICE OF 4 BRIGHT COLORS
  - High Efficiency Red
  - Orange
  - Yellow
  - High Performance Green
- POPULAR T-1 DIAMETER PACKAGE
- SELECTED MINIMUM INTENSITIES
- WIDE VIEWING ANGLE
- GENERAL PURPOSE LEADS
- RELIABLE AND RUGGED
- AVAILABLE ON TAPE AND REEL



Description

This family of T-1 lamps is widely used in general purpose indicator applications. Diffusants, tints, and optical design are balanced to yield superior light output and wide viewing angles. Several intensity choices are available in each color for increased design flexibility.

Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1mm (0.040") DOWN THE LEADS.

Part Number HLMP-	Application	Minimum Intensity (mcd) at 10mA	Color (Material)
1300	General Purpose	1.0	High Efficiency Red (GaAsP on GaP)
1301	General Purpose	2.0	
1302	High Ambient	3.0	
1385	Premium Lamp	6.0	
K400	General Purpose	1.0	Orange (GaAsP on GaP)
K401	High Ambient	2.0	
K402	Premium Lamp	3.0	
1400	General Purpose	1.0	Yellow (GaAsP on GaP)
1401	General Purpose	2.0	
1402	High Ambient	3.0	
1485	Premium Lamp	6.0	
1503	General Purpose	1.0	Green (GaP)
1523	High Ambient	2.6	
1585	Premium Lamp	4.0	

Electrical Characteristics at $T_A = 25°C$

Symbol	Description	Device	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	High Efficiency Red				mcd	$I_F = 10$ mA
		1300	1.0	2.0			
		1301	2.0	2.5			
		1302	3.0	4.0			
		1385	6.0	10.0			
		Orange					
		K400	1.0	2.0			
		K401	2.0	2.5			
		K402	3.0	4.0			
		Yellow					
		1400	1.0	2.0			
		1401	2.0	3.0			
		1402	3.0	4.0			
		1485	6.0	10.0			
		Green					
		1503	1.0	2.0			
		1523	2.6	4.0			
		1585	4.0	6.0			
$2\Theta 1/2$	Including Angle Between Half Luminous Intensity Points	All		60		Deg.	$I_F = 10$ mA See Note 1
λ_{PEAK}	Peak Wavelength	High Efficiency Red		635		nm	Measurement at Peak
		Orange		603			
		Yellow		583			
		Green		565			
λd	Dominant Wavelength	High Efficiency Red		626		nm	See Note 2
		Orange		608			
		Yellow		585			
		Green		569			
$\Delta\lambda 1/2$	Spectral Line Halfwidth	High Efficiency Red		40		nm	
		Yellow		36			
		Green		28			
τs	Speed of Response	High Efficiency Red		90		ns	
		Orange		280			
		Yellow		90			
		Green		500			
C	Capacitance	High Efficiency Red		11		pF	$V_F = 0$; f = 1 MHz
		Orange		4			
		Yellow		15			
		Green		18			
θ_{JC}	Thermal Resistance	All		120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	HER/Orange	1.5	2.2	3.0	V	$I_F = 10$ mA
		Yellow	1.5	2.2	3.0		
		Green	1.5	2.3	3.0		
V_R	Reverse Breakdown Volt.	All	5.0			V	$I_R = 100\ \mu A$
ηv	Luminous Efficacy	High Efficiency Red		145		$\frac{\text{lumens}}{\text{Watt}}$	See Note 3
		Orange		262			
		Yellow		500			
		Green		595			

NOTES:

1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	HER/Orange	Yellow	Green	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Reverse Voltage ($I_R = 100\ \mu A$)	5	5	5	V
Transient Forward Current[4] (10 μsec Pulse)	500	500	500	mA
Operating Temperature Range	-55 to +100	-55 to +100	-20 to +100	°C
Storage Temperature Range			-55 to +100	
Lead Soldering Temperature [1.6 mm (0.063 in.) from body]	260° C for 5 seconds			

NOTES:

1. See Figure 5 (Red/Orange), 10 (Yellow) or 15 (Green) to establish pulsed operating conditions.
2. For Red, Orange, and Green series derate linearly from 50° C at 0.5 mA/° C. For Yellow series derate linearly from 50° C at 0.2 mA/° C.
3. For Red, Orange, and Green series derate power linearly from 25° C at 1.8 mW/° C. For Yellow series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

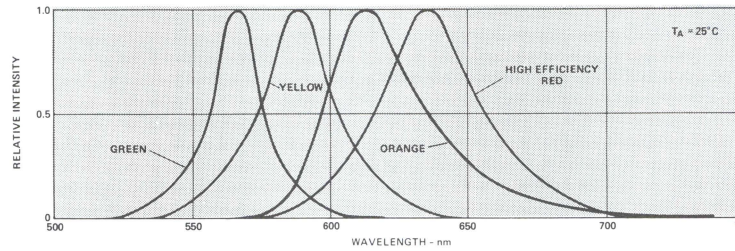


Figure 1. Relative Intensity vs. Wavelength

T-1 High Efficiency Red, Orange Diffused Lamps

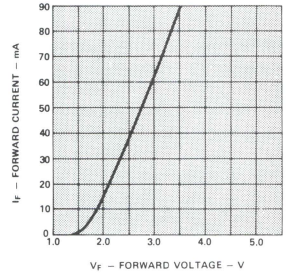


Figure 2. Forward Current vs. Forward Voltage Characteristics.

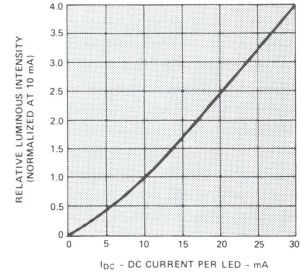


Figure 3. Relative Luminous Intensity vs. DC Forward Current.

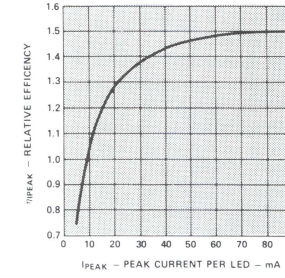


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current.

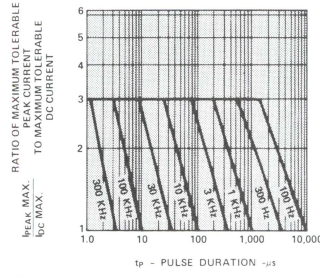


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings).

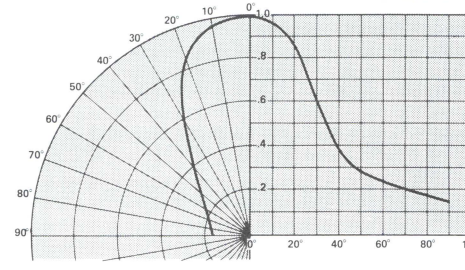


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

T-1 Yellow Diffused Lamps

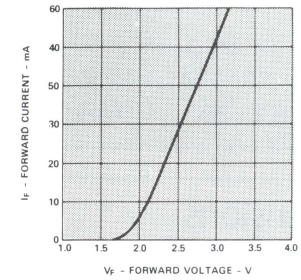


Figure 7. Forward Current vs. Forward Voltage Characteristics.

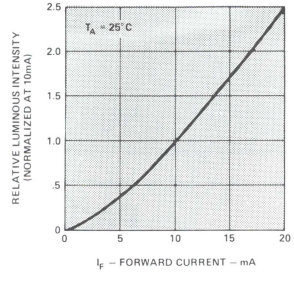


Figure 8. Relative Luminous Intensity vs. Forward Current.

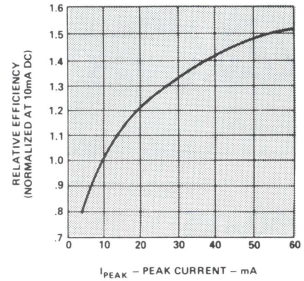


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

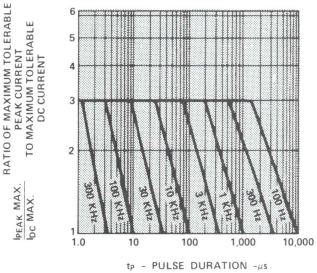


Figure 10. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings.)

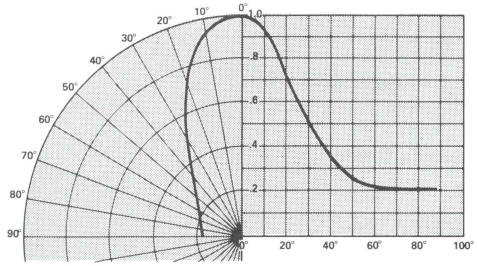


Figure 11. Relative Luminous Intensity vs. Angular Displacement.

T-1 Green Diffused Lamps

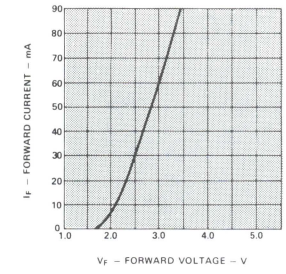


Figure 12. Forward Current vs. Forward Voltage Characteristics.

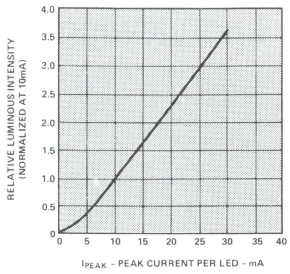


Figure 13. Relative Luminous Intensity vs. Forward Current.

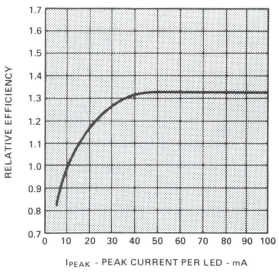


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current.

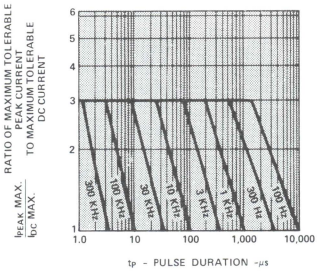


Figure 15. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings.)

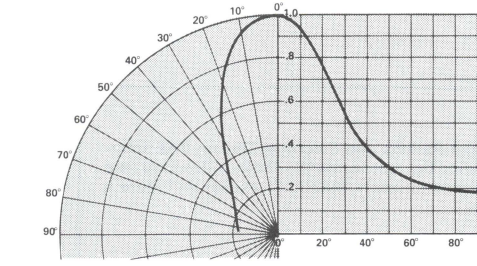


Figure 16. Relative Luminous Intensity vs. Angular Displacement.

SOLID STATE LAMPS

HEWLETT PACKARD

LOW PROFILE T-1 (3mm) LED LAMPS

High Efficiency Red HLMP-1350
Yellow HLMP-1450
High Performance Green HLMP-1550

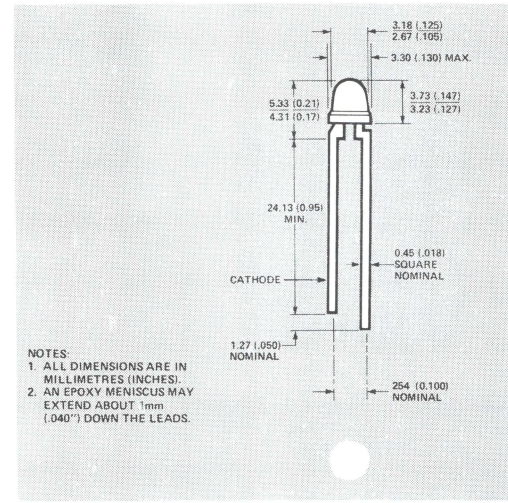
Features

- **LOW PROFILE HEIGHT**
- **SMALL T-1 SIZE DIAMETER 3.18 mm (.125 inch)**
- **HIGH INTENSITY**
- **IC COMPATIBLE**
- **CHOICE OF 3 BRIGHT COLORS**
  High Efficiency Red
  Yellow
  High Performance Green

Description

This family of solid state lamps is especially suited for applications where small package size is required without sacrificing luminous intensity. The HLMP-1350 is a red tinted, diffused lamp providing a wide viewing angle. The HLMP-1450 and HLMP-1550 are similar products in yellow and green respectively.

Package Dimensions



Axial Luminous Intensity and Viewing Angle @ 25°C

Part Number HLMP-	Description	I_V (mcd)		Test Condition mA	2Θ1/2 (Typ.) [1]	λd (nm-Typ.) [2]	Color
		Min.	Typ.				
1350	Tinted, Wide Angle	1.0	2.0	10	55°	626	High Efficiency Red
1450	Tinted, Wide Angle	1.0	2.0	10	55°	585	Yellow
1550	Tinted, Wide Angle	1.0	2.0	10	55°	569	Green

NOTES:
1. Θ1/2 is the off-axis angle at which the luminous intensity is half the axial intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.

For Maximum Ratings and Electrical/Optical Characteristics (including figures) see HLMP-1300/-1400/-1500 data sheet, publication number 5953-7735, except for Figure A shown here.

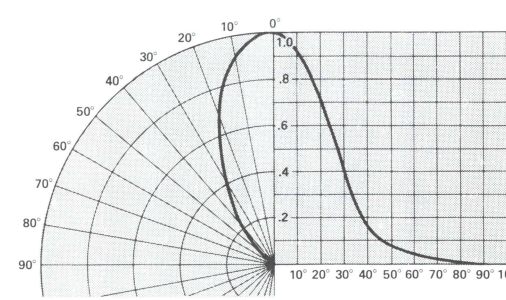


Figure A. Relative Luminous Intensity vs. Angular Displacement.

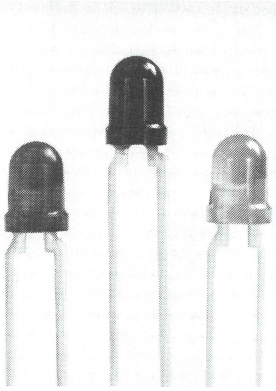
HEWLETT PACKARD

T-1 (3 mm) HIGH INTENSITY SOLID STATE LAMPS

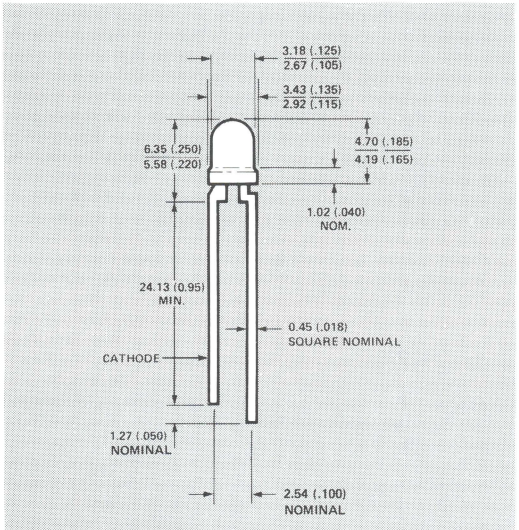
HIGH EFFICIENCY RED • HLMP-132X SERIES
YELLOW • HLMP-142X SERIES
HIGH PERFORMANCE GREEN • HLMP-152X SERIES

Features

- HIGH INTENSITY
- CHOICE OF 3 BRIGHT COLORS
  - High Efficiency Red
  - Yellow
  - High Performance Green
- POPULAR T-1 DIAMETER PACKAGE
- SELECTED MINIMUM INTENSITIES
- NARROW VIEWING ANGLE
- GENERAL PURPOSE LEADS
- RELIABLE AND RUGGED
- AVAILABLE ON TAPE AND REEL



Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1mm (.040") DOWN THE LEADS.

Description

This family of T-1 lamps is specially designed for applications requiring higher on-axis intensity than is achievable with a standard lamp. The light generated is focused to a narrow beam to achieve this effect.

Part Number HLMP-	Description	Minimum Intensity (mcd) at 10 mA	Color (Material)
1320	Untinted Non-Diffused	8.6	High Efficiency Red (GaAsP on GaP)
1321	Tinted Non-Diffused	8.6	
1420	Untinted Non-Diffused	9.2	Yellow (GaAsP on GaP)
1421	Tinted Non-Diffused	6.0	
1520	Untinted Non-Diffused	4.2	Green (GaP)
1521	Tinted Non-Diffused	4.2	

SOLID STATE LAMPS

Electrical Characteristics at $T_A = 25°C$

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	1320 1321	8.6 8.6	12.0 12.0		mcd	I_F = 10 mA (Figure 3)
		1420 1421	9.2 6.0	12.0 12.0		mcd	I_F = 10 mA (Figure 8)
		1520 1521	4.2 4.2	5.0 5.0		mcd	I_F = 10 mA (Figure 3)
$2\Theta_{1/2}$	Including Angle Between Half Luminous Intensity Points	All		45		Deg.	I_F = 10 mA See Note 1 (Figures 6, 11, 16, 21)
λ_{PEAK}	Peak Wavelength	132X 142X 152X		635 583 565		nm	Measurement at Peak (Figure 1)
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth	132X 142X 152X		40 36 28		nm	
λ_d	Dominant Wavelength	132X 142X 152X		626 585 569		nm	See Note 2 (Figure 1)
τ_S	Speed of Response	132X 142X 152X		90 90 500		ns	
C	Capacitance	132X 142X 152X		11 15 18		pF	V_F = 0; f = 1 MHz
θ_{JC}	Thermal Resistance	All		120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	132X 142X 152X	1.5 1.5 1.5	2.2 2.2 2.3	3.0 3.0 3.0	V	I_F = 10 mA
V_R	Reverse Breakdown Voltage	All	5.0			V	I_R = 100 μA
η_V	Luminous Efficacy	132X 142X 152X		145 500 595		$\frac{\text{lumens}}{\text{Watt}}$	See Note 3

Notes:

1. $\Theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	Red	Yellow	Green	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Reverse Voltage (I_R = 100 μA)	5	5	5	V
Transient Forward Current[4] (10 μsec Pulse)	500	500	500	mA
Operating Temperature Range	−55 to +100	−55 to +100	−20 to +100	°C
Storage Temperature Range			−55 to +100	
Lead Soldering Temperature [1.6 mm (0.063 in.) from body]	260° C for 5 seconds			

NOTES:

1. See Figure 5 (Red), 10 (Yellow), or 15 (Green) to establish pulsed operating conditions.
2. For Red and Green series derate linearly from 50° C at 0.5 mA/° C. For Yellow series derate linearly from 50° C at 0.2 mA/° C.
3. For Red and Green series derate power linearly from 25° C at 1.8 mW/° C. For Yellow series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

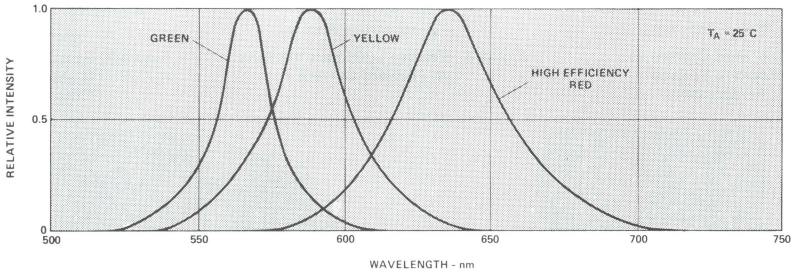


Figure 1. Relative Intensity vs. Wavelength

T-1 High Efficiency Red Non-Diffused

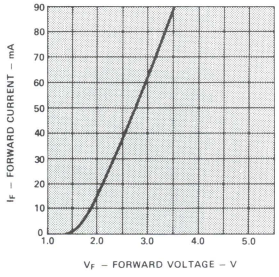


Figure 2. Forward Current vs. Forward Voltage Characteristics

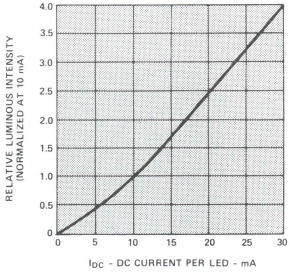


Figure 3. Relative Luminous Intensity vs. DC Forward Current

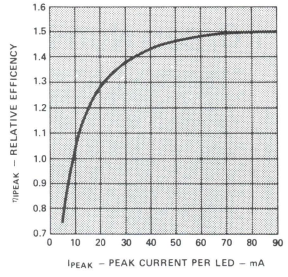


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

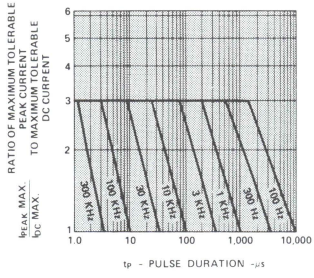


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC}MAX as per MAX Ratings)

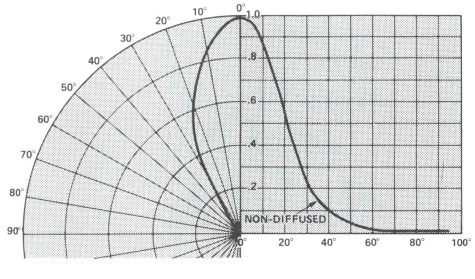


Figure 6. Relative Luminous Intensity vs. Angular Displacement

T-1 Yellow Non-Diffused

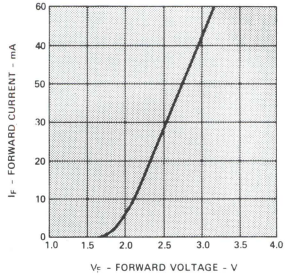


Figure 7. Forward Current vs. Forward Voltage Characteristics

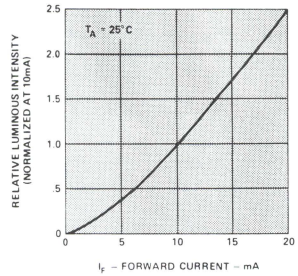


Figure 8. Relative Luminous Intensity vs. Forward Current

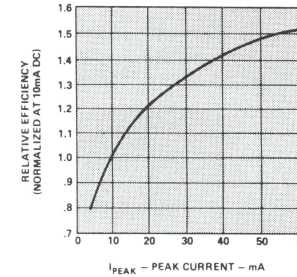


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current

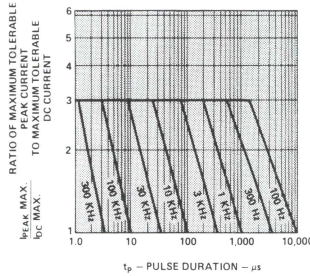


Figure 10. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC}MAX as per MAX Ratings)

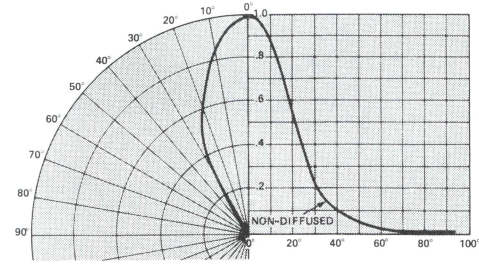


Figure 11. Relative Luminous Intensity vs. Angular Displacement

T-1 Green Non-Diffused

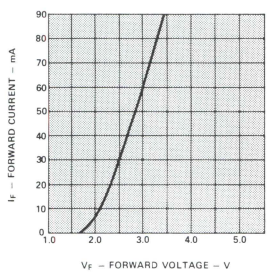


Figure 12. Forward Current vs. Forward Voltage Characteristics

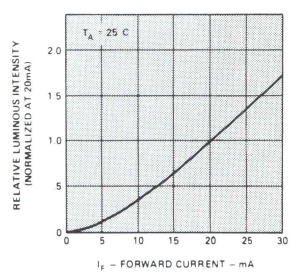


Figure 13. Relative Luminous Intensity vs. Forward Current

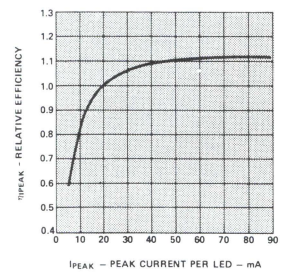


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

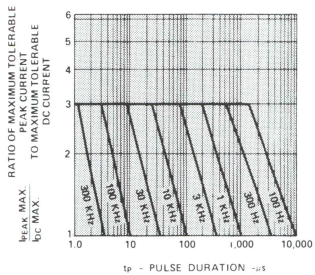


Figure 15. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC}MAX as per MAX Ratings)

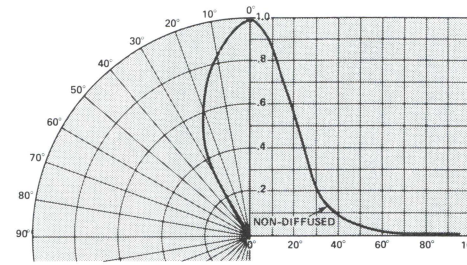


Figure 16. Relative Luminous Intensity vs. Angular Displacement

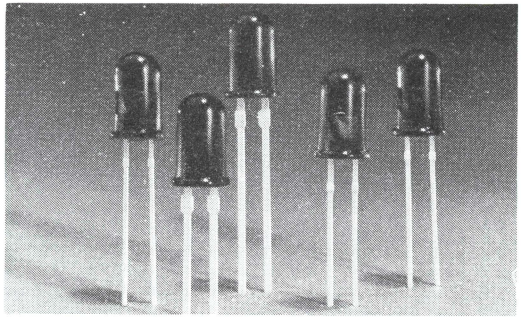
HEWLETT PACKARD

T-1 3/4 (5mm) RED SOLID STATE LAMPS

HLMP-3000
HLMP-3001
HLMP-3002
HLMP-3003
HLMP-3050

Features

- **LOW COST, BROAD APPLICATIONS**
- **LONG LIFE, SOLID STATE RELIABILITY**
- **LOW POWER REQUIREMENTS: 20 mA @ 1.6V**
- **HIGH LIGHT OUTPUT:**
  2.0 mcd Typical for HLMP-3000
  4.0 mcd Typical for HLMP-3001
- **WIDE AND NARROW VIEWING ANGLE TYPES**
- **RED DIFFUSED AND NON-DIFFUSED VERSIONS**



Description

The HLMP-3000 series lamps are Gallium Arsenide Phosphide light emitting diodes intended for High Volume/ Low Cost applications such as indicators for appliances, smoke detectors, automobile instrument panels and many other commercial uses.

The HLMP-3000/-3001/-3002/-3003 have red diffused lenses where as the HLMP-3050 has a red non-diffused lens. These lamps can be panel mounted using mounting clip HLMP-0103. The HLMP-3000/-3001 lamps have .025" leads and the HLMP-3002/-3003/-3050 have .018" leads.

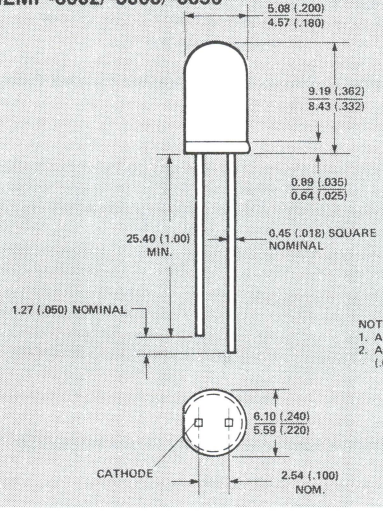
Absolute Maximum Ratings at $T_A = 25°C$

Parameter	3000 Series	Units
Power Dissipation	100	mW
DC Forward Current (Derate linearly from 50° C at 0.2 mA/° C)	50	mA
Average Forward Current	50	mA
Peak Operating Forward Current	1000	mA
Reverse Voltage (I_R = 100 μA)	5	V
Transient Forward Current[1] (10 μsec Pulse)	2000	mA
Operating and Storage Temperature Range	–55° C to +100° C	
Lead Solder Temperature (1.6 mm [0.063 inch] below package base)	260° C for 5 seconds	

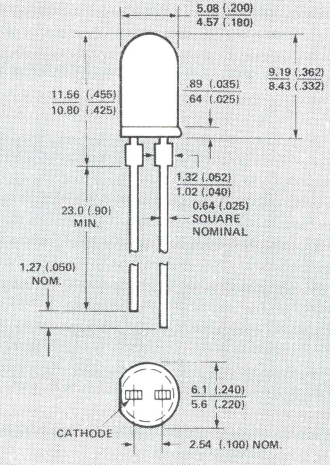
NOTES:
1. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

Package Dimensions

HLMP-3002/-3003/-3050



HLMP-3000/-3001



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1mm (.040") DOWN THE LEADS.

SOLID STATE LAMPS

Electrical Characteristics at T_A=25°C

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	3000/3002	1.0	2.0		mcd	I_F = 20 mA
		3001/3003	2.0	4.0		mcd	I_F = 20 mA
		3050	1.0	2.5		mcd	I_F = 20 mA
$2\Theta_{1/2}$	Included Angle Between Half Luminous Intensity Points	3000/3002		60		Deg.	I_F = 20 mA
		3001/3003		60			
		3050		24			
λ_P	Peak Wavelength	3000/3002		655		nm	Measurement at Peak
		3001/3003		655			
		3050		655			
λ_d	Dominant Wavelength	3000/3002		648		nm	
		3001/3003					
		3050					
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth	3000/3002		24		nm	
		3001/3003					
		3050					
τ_S	Speed of Response	3000/3002		10		ns	
		3001/3003					
		3050					
C	Capacitance	3000/3002		100		pF	V_F = 0, f = 1 MHz
		3001/3003					
		3050					
Θ_{JC}	Thermal Resistance	3000/3001		95		°C/W	Junction to Cathode Lead
		3002/3003		120			
		3050		120			
V_F	Forward Voltage	3000/3002	1.4	1.6	2.0	V	I_F = 20 mA (Fig. 2)
		3001/3003					
		3050					
V_R	Reverse Breakdown Voltage	3000/3002	5.0			V	I_R = 100 μA
		3001/3003					
		3050					

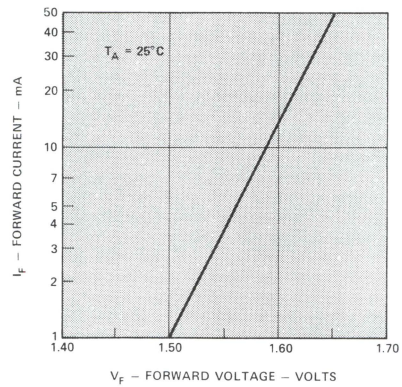


Figure 1. Forward Current Versus Forward Voltage

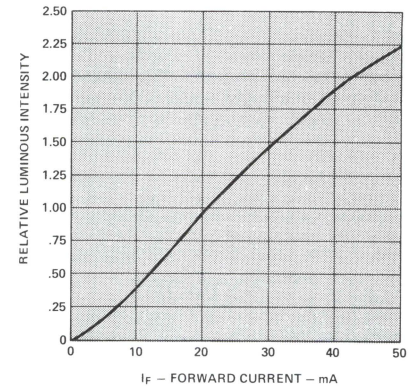


Figure 2. Relative Luminous Intensity Versus Forward Current

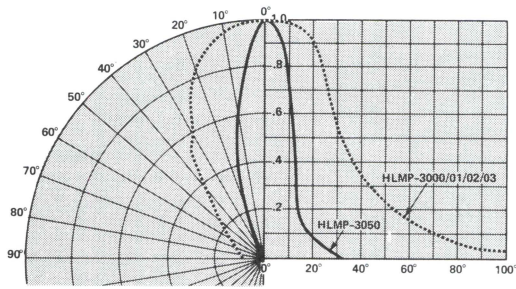


Figure 3. Relative Luminous Intensity Versus Angular Displacement.

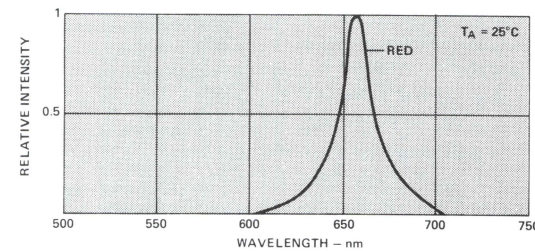


Figure 4. Relative Luminous Intensity Versus Wavelength.

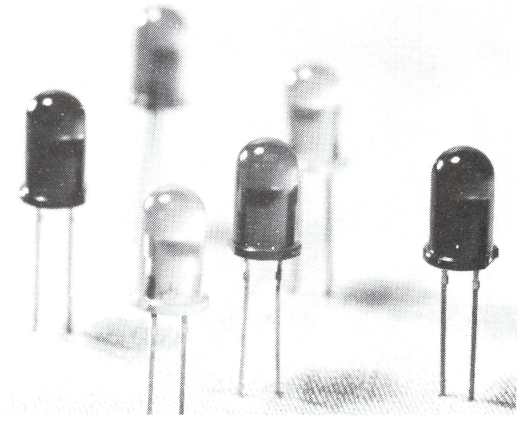
HEWLETT PACKARD

T-1 3/4 (5mm) DIFFUSED SOLID STATE LAMPS

HIGH EFFICIENCY RED • HLMP-3300 SERIES
ORANGE • HLMP-D400 SERIES
YELLOW • HLMP-3400 SERIES
HIGH PERFORMANCE GREEN • HLMP-3500 SERIES

Features

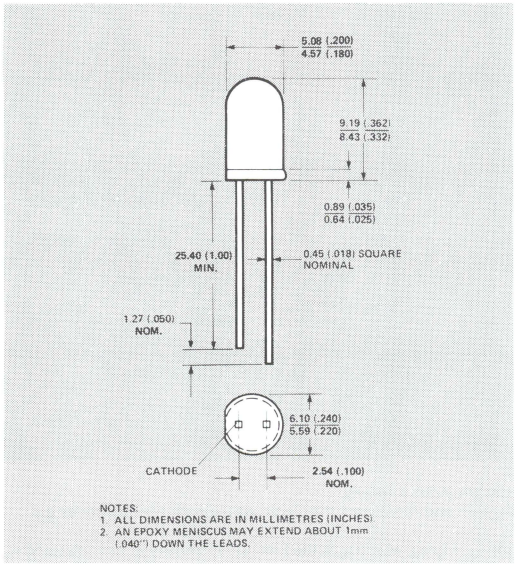
- **HIGH INTENSITY**
- **CHOICE OF 4 BRIGHT COLORS**
  - **High Efficiency Red**
  - **Orange**
  - **Yellow**
  - **High Performance Green**
- **POPULAR T-1¾ DIAMETER PACKAGE**
- **SELECTED MINIMUM INTENSITIES**
- **WIDE VIEWING ANGLE**
- **GENERAL PURPOSE LEADS**
- **RELIABLE AND RUGGED**
- **AVAILABLE ON TAPE AND REEL**



Description

This family of T-1¾ lamps is widely used in general purpose indicator applications. Diffusants, tints, and optical design are balanced to yield superior light output and wide viewing angles. Several intensity choices are available in each color for increased design flexibility.

Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1mm (.040") DOWN THE LEADS.

Part Number HLMP-	Application	Minimum Intensity (mcd) at 10mA	Color (Material)
3300	General Purpose	2.1	High Efficiency Red (GaAsP on GaP)
3301	High Ambient	4.0	
3762	Premium Lamp	8.0	
D400	General Purpose	2.1	Orange (GaAsP on GaP)
D401	High Ambient	4.0	
3400	General Purpose	2.2	Yellow (GaAsP on GaP)
3401	High Ambient	4.0	
3862	Premium Lamp	8.0	
3502	General Purpose	1.6	Green (GaP) 565 nm
3507	High Ambient	4.2	
3962	Premium Lamp	8.0	

SOLID STATE LAMPS

Electrical Characteristics at $T_A = 25°C$

Symbol	Parameter	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	High Efficiency Red				mcd	I_F = 10 mA
		3300	2.1	3.5			
		3301	4.0	7.0			
		3762	8.0	15.0			
		Orange					
		D400	2.1	3.5			
		D401	4.0	7.0			
		Yellow					
		3400	2.2	4.0			
		3401	4.0	8.0			
		3862	8.0	12.0			
		Green					
		3502	1.6	2.4			
		3507	4.2	5.2			
		3962	8.0	11.0			
$2\Theta_{1/2}$	Including Angle Between Half Luminous Intensity Points	High Efficiency Red		60		Deg.	I_F = 10 mA See Note 1
		Orange		60			
		Yellow		60			
		Green		60			
λ_{PEAK}	Peak Wavelength	High Efficiency Red		635		nm	Measurement at Peak
		Orange		612			
		Yellow		583			
		Green		565			
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth	HER/Orange		40		nm	
		Yellow		36			
		Green		28			
λ_d	Dominant Wavelength	High Efficiency Red		626		nm	See Note 2
		Orange		608			
		Yellow		585			
		Green		569			
τ_s	Speed of Response	High Efficiency Red		90		ns	
		Orange		280			
		Yellow		90			
		Green		500			
C	Capacitance	High Efficiency Red		11		pF	V_F = 0; f = 1 MHz
		Orange		4			
		Yellow		15			
		Green		18			
θ_{JC}	Thermal Resistance	All		140		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	HER/Orange	1.5	2.2	3.0	V	I_F = 10 mA
		Yellow	1.5	2.2	3.0		
		Green	1.5	2.3	3.0		
V_R	Reverse Breakdown Voltage	All	5.0			V	I_R = 100 μA
η_V	Luminous Efficacy	High Efficiency Red		145		$\frac{\text{lumens}}{\text{Watt}}$	See Note 3
		Orange		262			
		Yellow		500			
		Green		595			

NOTES:

1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	HER/Orange	Yellow	Green	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Reverse Voltage ($I_R = 100\ \mu A$)	5	5	5	V
Transient Forward Current[4] (10 μsec Pulse)	500	500	500	mA
Operating Temperature Range	-55 to +100	-55 to +100	-20 to +100	°C
Storage Temperature Range			-55 to +100	
Lead Soldering Temperature [1.6 mm (0.063 in.) from body]	260° C for 5 seconds			

NOTES:

1. See Figure 5 (Red/Orange), 10 (Yellow) or 15 (Green) to establish pulsed operating conditions.
2. For Red, Orange, and Green series derate linearly from 50° C at 0.5 mA/° C. For Yellow series derate linearly from 50° C at 0.2 mA/° C.
3. For Red, Orange, and Green series derate power linearly from 25° C at 18 mW/° C. For Yellow series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

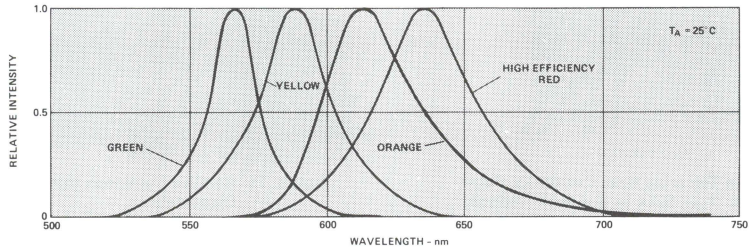


Figure 1. Relative Intensity vs. Wavelength

T-1¾ High Efficiency Red, Orange Diffused Lamps

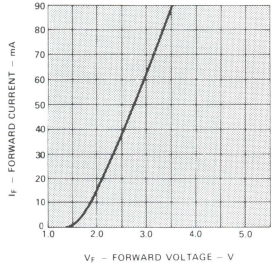


Figure 2. Forward Current vs. Forward Voltage Characteristics.

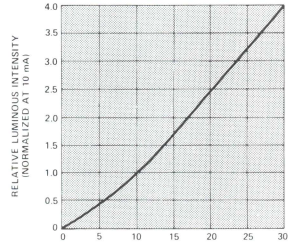


Figure 3. Relative Luminous Intensity vs. DC Forward Current.

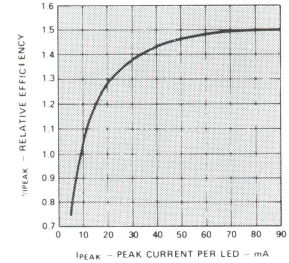


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. LED Peak Current.

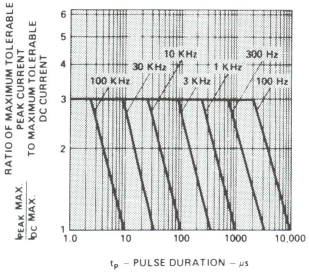


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings

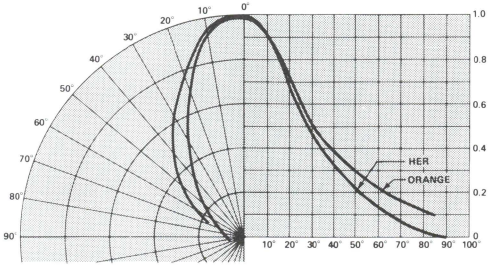


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

SOLID STATE LAMPS

T-1¾ Yellow Diffused Lamps

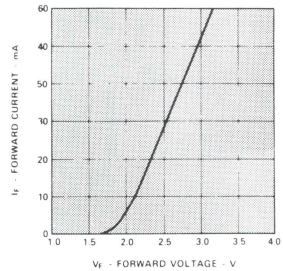


Figure 7. Forward Current vs. Forward Voltage Characteristics.

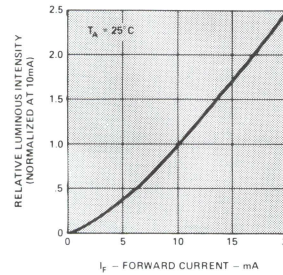


Figure 8. Relative Luminous Intensity vs. Forward Current.

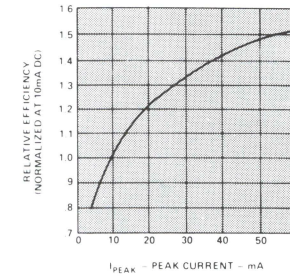


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

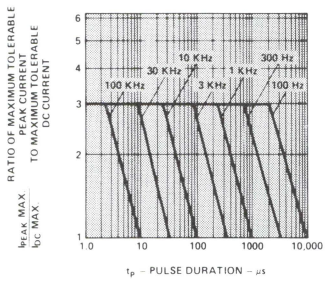


Figure 10. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

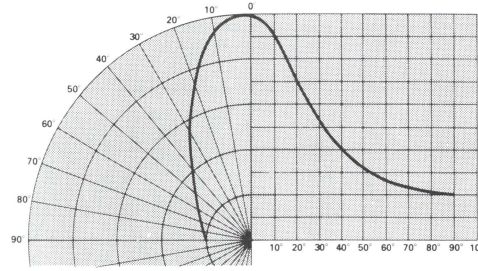


Figure 11. Relative Luminous Intensity vs. Angular Displacement.

T-1¾ Green Diffused Lamps

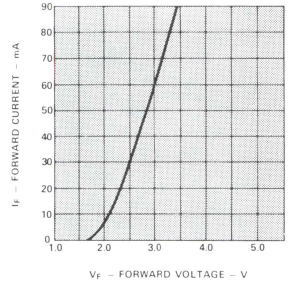


Figure 12. Forward Current vs. Forward Voltage Characteristics.

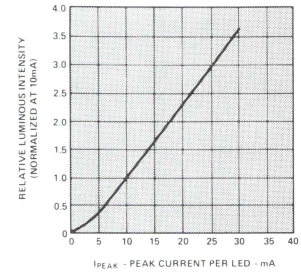


Figure 13. Relative Luminous Intensity vs. DC Forward Current.

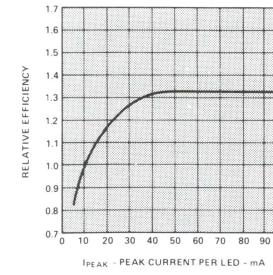


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current.

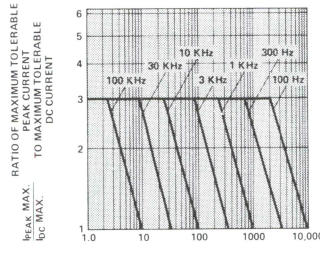


Figure 15. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

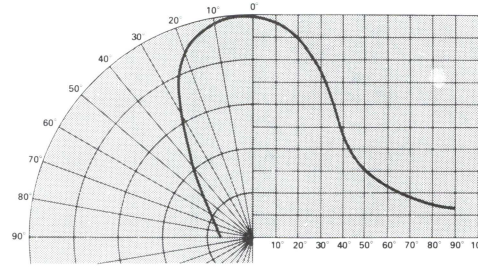


Figure 16. Relative Luminous Intensity vs. Angular Displacement.

HEWLETT PACKARD

T-1 3/4 (5mm) LOW PROFILE SOLID STATE LAMPS

RED ● HLMP-3200 SERIES
HIGH EFFICIENCY RED ● HLMP-3350 SERIES
YELLOW ● HLMP-3450 SERIES
HIGH PERFORMANCE GREEN ● HLMP-3550 SERIES

Features

- **HIGH INTENSITY**
- **LOW PROFILE: 5.8mm (0.23 in) NOMINAL**
- **T-1¾ DIAMETER PACKAGE**
- **DIFFUSED AND NON-DIFFUSED TYPES**
- **GENERAL PURPOSE LEADS**
- **IC COMPATIBLE/LOW CURRENT REQUIREMENTS**
- **RELIABLE AND RUGGED**

Description

The HLMP-3200 Series are Gallium Arsenide Phosphide Red Light Emitting Diodes with a red diffused lens.

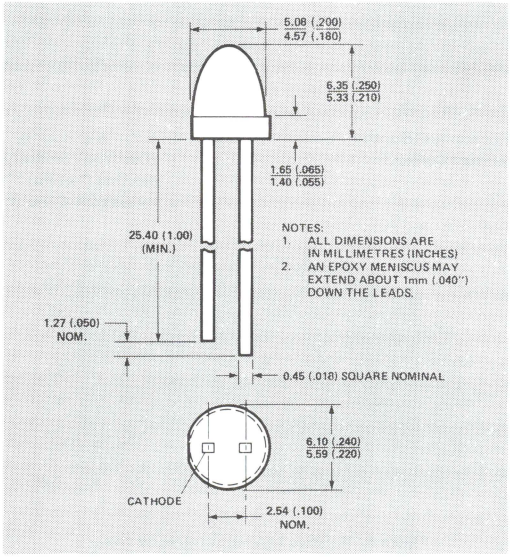
The HLMP-3350 Series are Gallium Arsenide Phosphide on Gallium Phosphide High Efficiency Red Light Emitting Diodes.

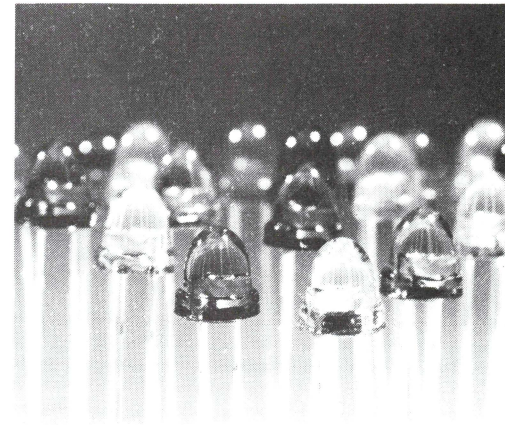
The HLMP-3450 Series are Gallium Arsenide Phosphide on Gallium Phosphide Yellow Light Emitting Diodes.

The HLMP-3550 Series are Gallium Phosphide Green Light Emitting Diodes.

The Low Profile T-1¾ package provides space savings and is excellent for backlighting applications.

Package Dimensions





Number HLMP-	Application	Minimum Intensity @ 10 mA (mcd)	Lens
3200	Indicator — General Purpose	1.0	Tinted Diffused Wide Angle Red
3201	Indicator — High Brightness	2.0	
3350	Indicator — General Purpose	2.0	Tinted Diffused Wide Angle HER
3351	Indicator — High Brightness	5.0	
3365	General Purpose Point Source	7.0	Tinted Non-diffused Narrow Angle HER
3366	Indicator — High Brightness	12.0	
3450	Indicator — General Purpose	2.5	Tinted Diffused Wide Angle Yellow
3451	Indicator — High Brightness	6.0	
3465	General Purpose Point Source	6.0	Tinted Non-diffused Narrow Angle Yellow
3201	Indicator — High Brightness	12.0	
3553	Indicator — General Purpose	1.6	Tinted Diffused Wide Angle Green
3554	Indicator — High Brightness	6.7	
3567	General Purpose Point Source	4.2	Tinted Non-diffused Narrow Angle Green
3568	Indicator — High Brightness	10.6	

SOLID STATE LAMPS

RED HLMP-3200 SERIES

Electrical Specifications at T_A=25°C

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Axial Luminous Intensity	3200	1.0	2.0		mcd	I_F = 20 mA (Figure 3)
		3201	2.0	4.0			
$2\theta_{1/2}$	Included Angle Between Half Luminous Intensity Points			60		deg.	Note 1 (Figure 6)
λ_{PEAK}	Peak Wavelength			655		nm	Measurement at Peak (Fig. 1)
λ_d	Dominant Wavelength			648		nm	Note 2
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth			24		nm	
τ_s	Speed of Response			10		ns	
C	Capacitance			100		pF	V_F = 0; f = 1 MHz
θ_{JC}	Thermal Resistance			120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage		1.4	1.6	2.0	V	I_F = 20 mA (Fig. 2)
V_R	Reverse Breakdown Voltage		5.0			V	I_R = 100 μA
η_V	Luminous Efficacy			65		lm/W	Note 3

Notes: 1. $\theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity. 2. Dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device. 3. Radiant Intensity I_e, in watts/steradian may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

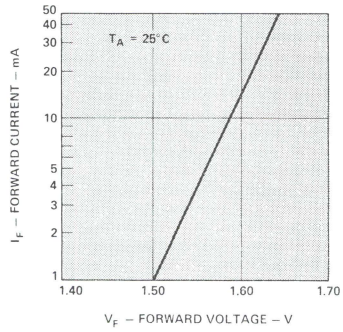


Figure 2. Forward Current versus Forward Voltage.

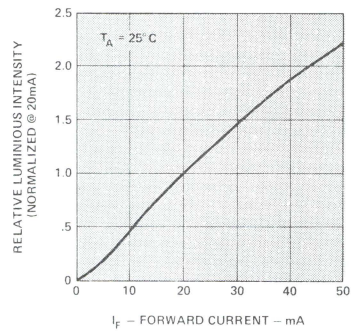


Figure 3. Relative Luminous Intensity versus Forward Current.

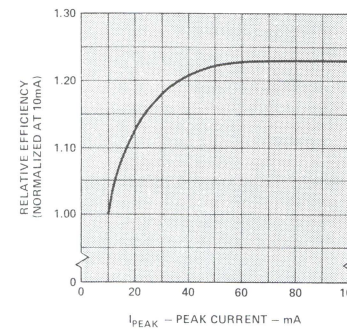


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) versus Peak Current.

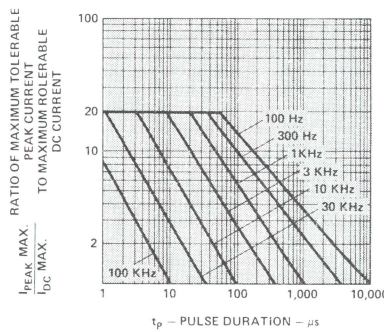


Figure 5. Maximum Tolerable Peak Current versus Pulse Duration. (I_{DC} MAX as per MAX Ratings)

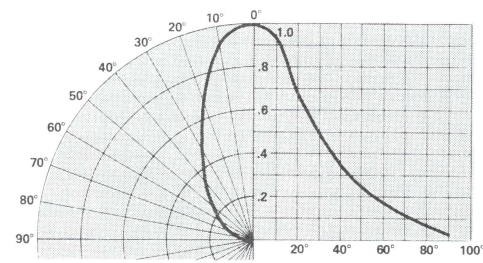


Figure 6. Relative Luminous Intensity versus Angular Displacement.

GREEN HLMP-3550 SERIES
Electrical Specifications at T_A=25°C

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Axial Luminous Intensity	3553 3554 3567 3568	1.6 6.7 4.2 10.6	3.2 10.0 7.0 15.0		mcd	I_F = 10 mA (Fig. 18)
$2\theta_{1/2}$	Included Angle Between Half Luminous Intensity Points	3553 3554 3567 3568		50 50 40 40		Deg.	Note 1 (Figure 21)
λ_{PEAK}	Peak Wavelength			565		nm	Measurement at Peak (Fig. 1)
λ_d	Dominant Wavelength			569		nm	Note 2
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth			28		nm	
τ_s	Speed of Response			500		ns	
C	Capacitance			18		pF	V_F = 0; f = 1 MHz
θ_{JC}	Thermal Resistance			120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage		1.5	2.3	3.0	V	I_F = 10 mA (Fig. 17)
V_R	Reverse Breakdown Voltage		5.0			V	I_R = 100 μA
η_V	Luminous Efficacy			595		lm/W	Note 3

Notes: 1. $\theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity. 2. Dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device. 3. Radiant Intensity I_e, in watts/steradian may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

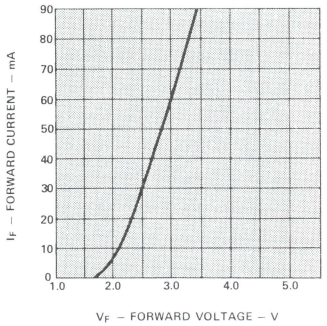


Figure 17. Forward Current versus Forward Voltage.

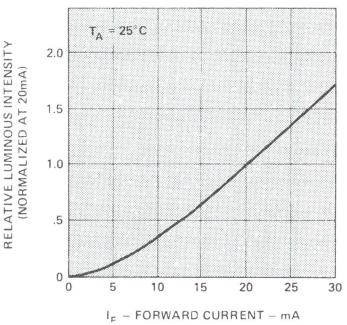


Figure 18. Relative Luminous Intensity versus Forward Current.

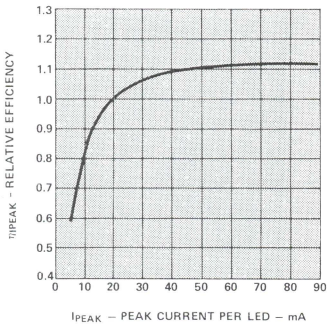


Figure 19. Relative Efficiency (Luminous Intensity per Unit Current) versus Peak Current.

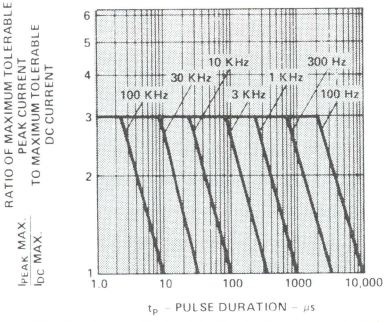


Figure 20. Maximum Tolerable Peak Current versus Pulse Duration. (I_{DC} MAX as per MAX ratings).

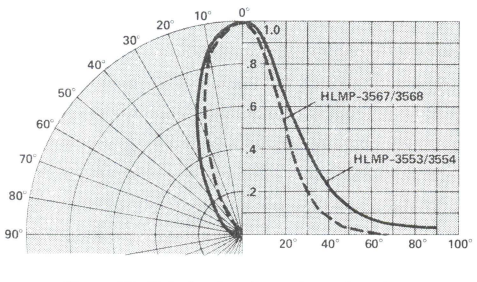


Figure 21. Relative Luminous Intensity versus Angular Displacement.

HIGH EFFICIENCY RED HLMP-3350 SERIES

Electrical Specifications at T_A=25°C

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Axial Luminous Intensity	3350 3351 3365 3366	2.0 5.0 7.0 12.0	3.5 7.0 10.0 18.0		mcd	I_F = 10 mA (Fig. 8)
$2\theta_{1/2}$	Included Angle Between Half Luminous Intensity Points	3350 3351 3365 3366		50 50 45 45		Deg.	Note 1 (Fig. 11)
λ_P	Peak Wavelength			635		nm	Measurement at Peak (Fig. 1)
λ_d	Dominant Wavelength			626		nm	Note 2
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth			40		nm	
τ_s	Speed of Response			90		ns	
C	Capacitance			16		pF	V_F = 0; f = 1 MHz
θ_{JC}	Thermal Resistance			120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage		1.5	2.2	3.0	V	I_F = 10 mA (Fig. 7)
V_R	Reverse Breakdown Voltage		5.0			V	I_R = 100 μA
η_v	Luminous Efficacy			145		lm/W	Note 3

Notes: 1. $\theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity. 2. Dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device. 3. Radiant Intensity I_e, in watts/steradian may be found from the equation $I_e = I_v/\eta_v$, where I_v is the luminous intensity in candelas and η_v is the luminous efficacy in lumens/watt.

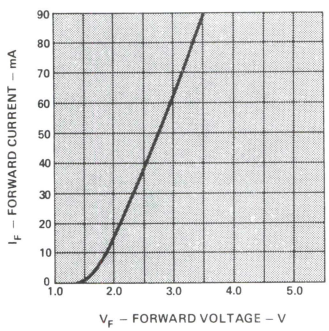


Figure 7. Forward Current versus Forward Voltage.

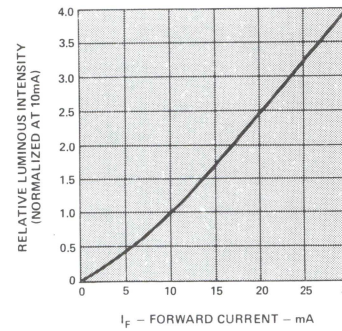


Figure 8. Relative Luminous Intensity versus Forward Current.

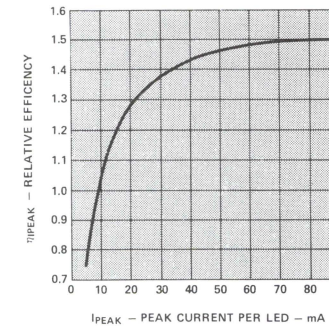


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) versus Peak Current.

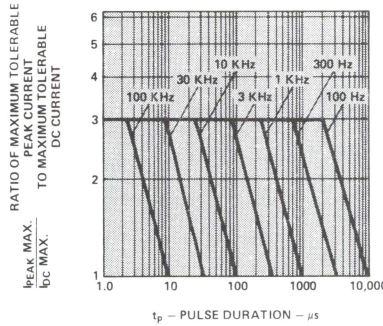


Figure 10. Maximum Tolerable Peak Current versus Pulse Duration. (I_{DC} MAX as per MAX Ratings)

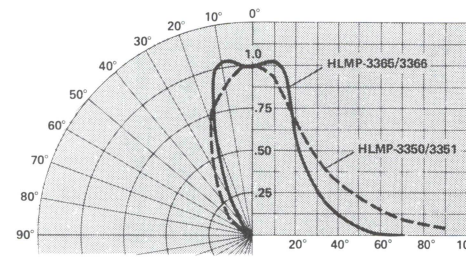


Figure 11. Relative Luminous Intensity versus Angular Displacement.

YELLOW HLMP-3450 SERIES
Electrical Specifications at T_A=25°C

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Axial Luminous Intensity	3450 3451 3465 3466	2.5 6.0 6.0 12.0	4.0 10.0 12.0 18.0		mcd	I_F = 10 mA (Fig. 13)
$2\theta_{1/2}$	Included Angle Between Half Luminous Intensity Points	3450 3451 3465 3466		50 50 45 45		Deg.	Note 1 (Fig. 16)
λ_P	Peak Wavelength			583		nm	Measurement at Peak (Fig. 1)
λ_d	Dominant Wavelength			585		nm	Note 2
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth			36		nm	
τ_S	Speed of Response			90		ns	
C	Capacitance			18		pF	V_F = 0; f = 1 MHz
θ_{JC}	Thermal Resistance			120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage		1.5	2.2	3.0	V	I_F = 10 mA (Fig. 12)
V_R	Reverse Breakdown Voltage		5.0			V	I_R = 100 μA
η_V	Luminous Efficacy			500		lm/W	Note 3

Notes: 1. $\theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity. 2. Dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device. 3. Radiant Intensity I_e, in watts/steradian may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

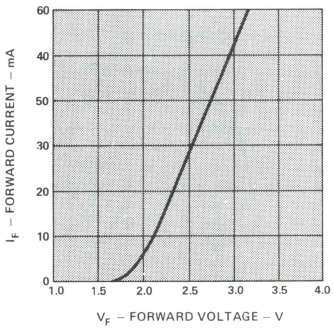


Figure 12. Forward Current versus Forward Voltage.

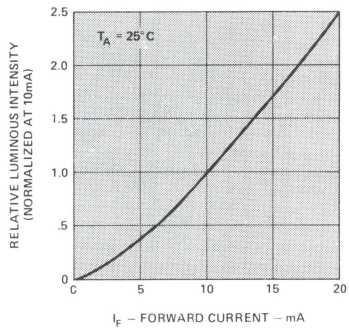


Figure 13. Relative Luminous Intensity versus Forward Current.

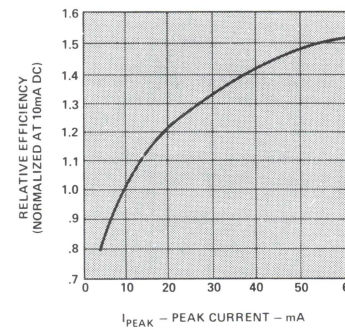


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) versus Peak Current.

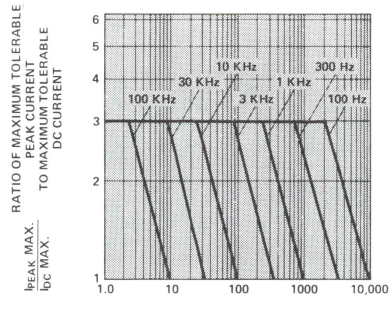


Figure 15. Maximum Tolerable Peak Current versus Pulse Duration. (I_{DC} MAX as per MAX Ratings).

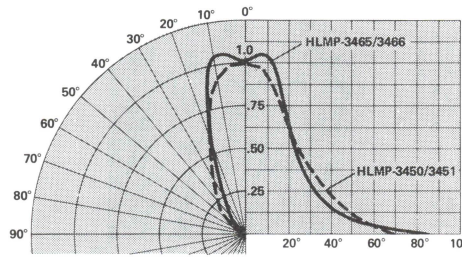


Figure 16. Relative Luminous Intensity versus Angular Displacement

SOLID STATE LAMPS

GREEN HLMP-3550 SERIES
Electrical Specifications at T_A=25°C

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Axial Luminous Intensity	3553 3554 3567 3568	1.6 6.7 4.2 10.6	3.2 10.0 7.0 15.0		mcd	I_F = 10 mA (Fig. 18)
$2\theta_{1/2}$	Included Angle Between Half Luminous Intensity Points	3553 3554 3567 3568		50 50 40 40		Deg.	Note 1 (Figure 21)
λ_P	Peak Wavelength			565		nm	Measurement at Peak (Fig. 1)
λ_d	Dominant Wavelength			569		nm	Note 2
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth			28		nm	
τ_s	Speed of Response			500		ns	
C	Capacitance			18		pF	V_F = 0; f = 1 MHz
θ_{JC}	Thermal Resistance			120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage		1.6	2.3	3.0	V	I_F = 10 mA (Fig. 17)
V_R	Reverse Breakdown Voltage		5.0			V	I_R = 100 μA
η_V	Luminous Efficacy			595		lm/W	Note 3

Notes: 1. $\theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity. 2. Dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device. 3. Radiant Intensity I_e, in watts/steradian may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

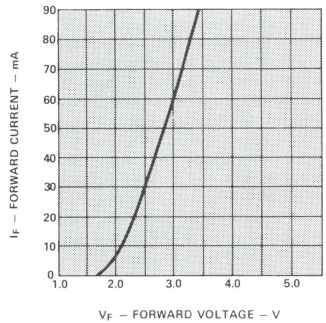


Figure 17. Forward Current versus Forward Voltage.

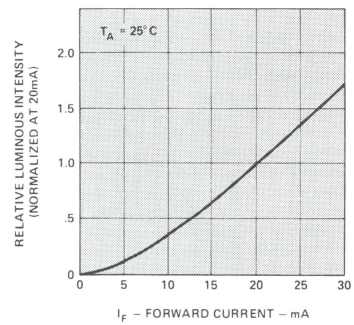


Figure 18. Relative Luminous Intensity versus Forward Current.

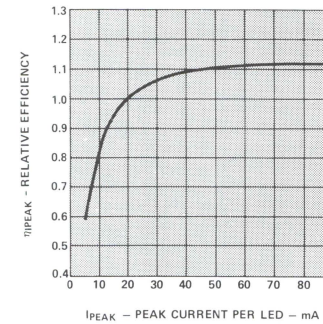


Figure 19. Relative Efficiency (Luminous Intensity per Unit Current) versus Peak Current.

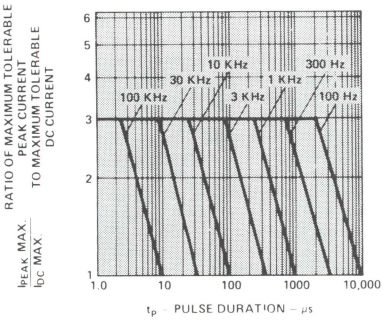


Figure 20. Maximum Tolerable Peak Current versus Pulse Duration. (I_{DC} MAX as per MAX ratings).

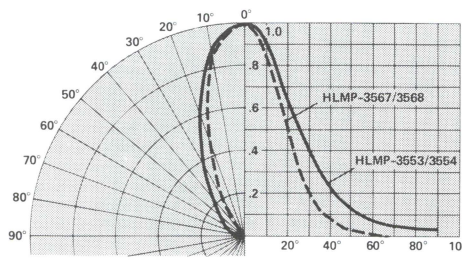


Figure 21. Relative Luminous Intensity versus Angular Displacement.

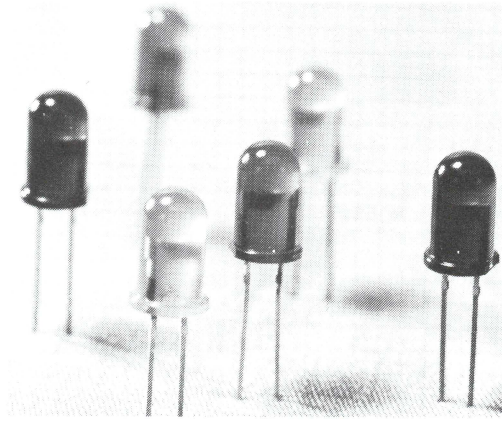
HEWLETT PACKARD

T-1 3/4 (5 mm) HIGH INTENSITY SOLID STATE LAMPS

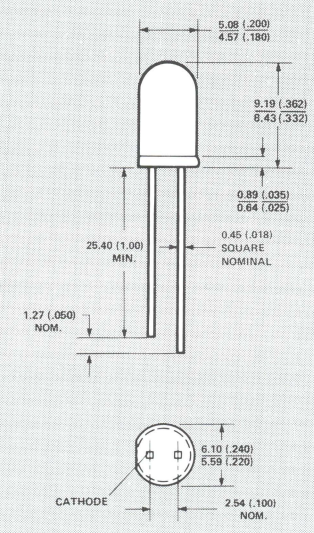
HIGH EFFICIENCY RED • HLMP-331X SERIES
YELLOW • HLMP-341X SERIES
HIGH PERFORMANCE GREEN • HLMP-351X SERIES

Features

- HIGH INTENSITY
- CHOICE OF 3 BRIGHT COLORS
  - High Efficiency Red
  - Yellow
  - High Performance Green
- POPULAR T-1 3/4 DIAMETER PACKAGE
- SELECTED MINIMUM INTENSITIES
- NARROW VIEWING ANGLE
- GENERAL PURPOSE LEADS
- RELIABLE AND RUGGED
- AVAILABLE ON TAPE AND REEL



Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1mm (.040") DOWN THE LEADS.

Description

This family of T-1 3/4 lamps is specially designed for applications requiring higher on-axis intensity than is achievable with a standard lamp. The light generated is focused to a narrow beam to achieve this effect.

Part Number HLMP-	Description	Minimum Intensity (mcd) at 10 mA	Color (Material)
3315	Illuminator/Point Source	12	High Efficiency Red (GaAsP on GaP)
3316	Illuminator/High Brightness	20	
3415	Illuminator/Point Source	10	Yellow (GaAsP on GaP)
3416	Illuminator/High Brightness	20	
3517	Illuminator/Point Source	6.7	Green (GaP)
3519	Illuminator/High Brightness	10.6	

SOLID STATE LAMPS

Electrical Characteristics at $T_A = 25°C$

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	3315 3316	12.0 20.0	18.0 30.0		mcd	I_F = 10 mA (Figure 3)
		3415 3416	10.0 20.0	18.0 30.0		mcd	I_F = 10 mA (Figure 8)
		3517 3519	6.7 10.6	10.0 25.0		mcd	I_F = 10 mA (Figure 3)
2Θ 1/2	Including Angle Between Half Luminous Intensity Points	3315 3316		35 35		Deg.	I_F = 10 mA See Note 1 (Figure 6)
		3415 3416		35 35		Deg.	I_F = 10 mA See Note 1 (Figure 11)
		3517 3519		24 24		Deg.	I_F = 10 mA See Note 1 (Figure 16)
λ_{PEAK}	Peak Wavelength	331X 341X 351X		635 583 565		nm	Measurement at Peak (Figure 1)
$\Delta\lambda$ 1/2	Spectral Line Halfwidth	331X 341X 351X		40 36 28		nm	
λ_d	Dominant Wavelength	331X 341X 351X		626 585 569		nm	See Note 2 (Figure 1)
τ_s	Speed of Response	331X 341X 351X		90 90 500		ns	
C	Capacitance	331X 341X 351X		11 15 18		pF	V_F = 0; f = 1 MHz
θ_{J_C}	Thermal Resistance	331X 341X 351X		120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	331X 341X 351X	1.5 1.5 1.5	2.2 2.2 2.3	3.0 3.0 3.0	V	I_F = 10 mA (Figure 2) I_F = 10 mA (Figure 7) I_F = 10 mA (Figure 12)
V_R	Reverse Breakdown Volt.	All	5.0			V	I_R = 100 μA
η_V	Luminous Efficacy	331X 341X 351X		145 500 595		lumens Watt	See Note 3

NOTES:
1. $\Theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	331X Series	341X Series	351X Series	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Reverse Voltage (I_R = 100 μA)	5	5	5	V
Transient Forward Current[4] (10 μsec Pulse)	500	500	500	mA
Operating Temperature Range	−55 to +100	−55 to +100	−20 to +100	°C
Storage Temperature Range			−55 to +100	
Lead Soldering Temperature [1.6 mm (0.063 in.) from body]	260° C for 5 seconds			

NOTES:
1. See Figure 5 (Red), 10 (Yellow), or 15 (Green) to establish pulsed operating conditions.
2. For Red and Green series derate linearly from 50° C at 0.5 mA/° C. For Yellow series derate linearly from 50° C at 0.2 mA/° C.
3. For Red and Green series derate power linearly from 25° C at 1.8 mW/° C. For Yellow series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

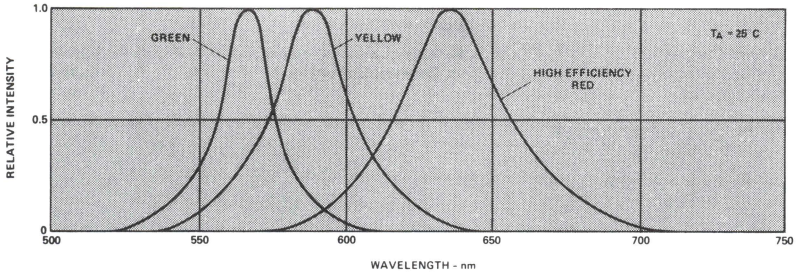


Figure 1. Relative Intensity vs. Wavelength

High Efficiency Red HLMP-331X Series

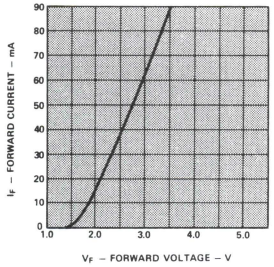


Figure 2. Forward Current vs. Forward Voltage Characteristics

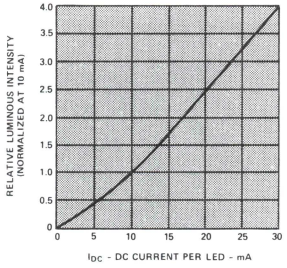


Figure 3. Relative Luminous Intensity vs. DC Forward Current

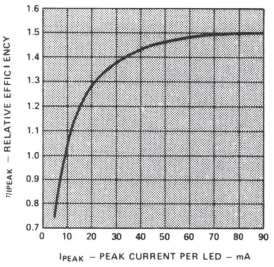


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

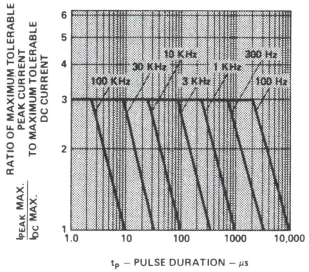


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration (I_{DC} MAX as per MAX Ratings)

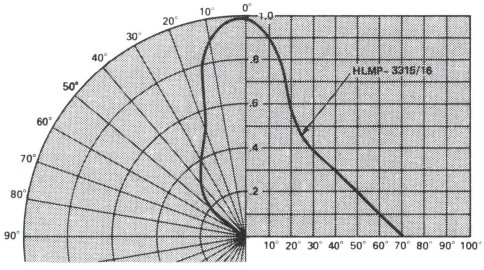


Figure 6. Relative Luminous Intensity vs. Angular Displacement

Yellow HLMP-341X Series

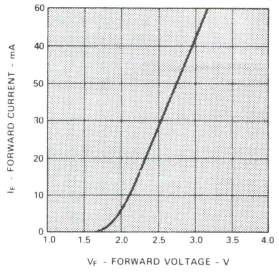


Figure 7. Forward Current vs. Forward Voltage Characteristics

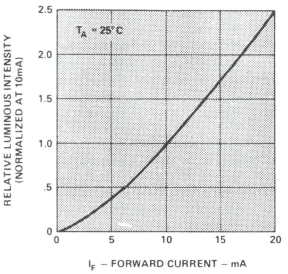


Figure 8. Relative Luminous Intensity vs. Forward Current

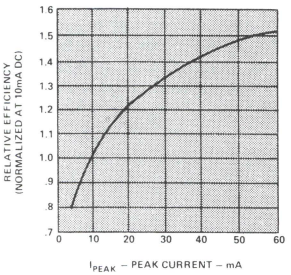


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current

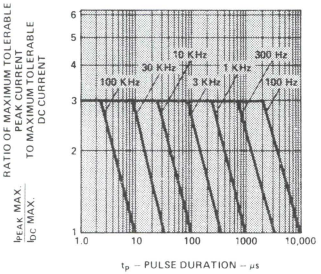


Figure 10. Maximum Tolerable Peak Current vs. Pulse Duration (I_{DC} MAX as per MAX Ratings)

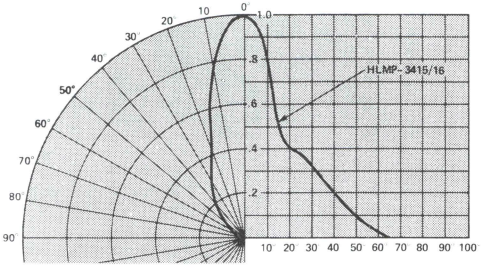


Figure 11. Relative Luminous Intensity vs. Angular Displacement

Green HLMP-351X Series

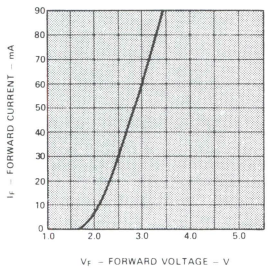


Figure 12. Forward Current vs. Forward Voltage Characteristics

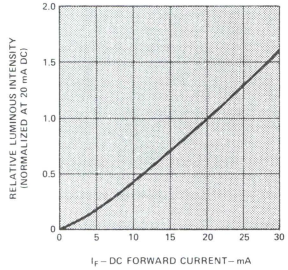


Figure 13. Relative Luminous Intensity vs. DC Forward Current

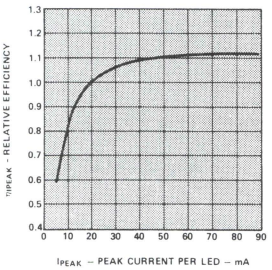


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

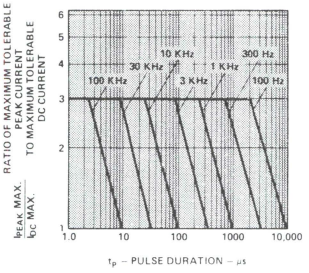


Figure 15. Maximum Tolerable Peak Current vs. Pulse Duration (I_{DC} MAX as per MAX Ratings)

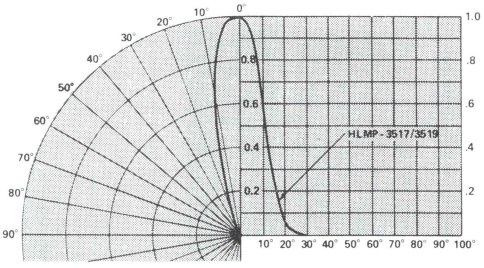


Figure 16. Relative Luminous Intensity vs. Angular Displacement. T-1 3/4 Lamp

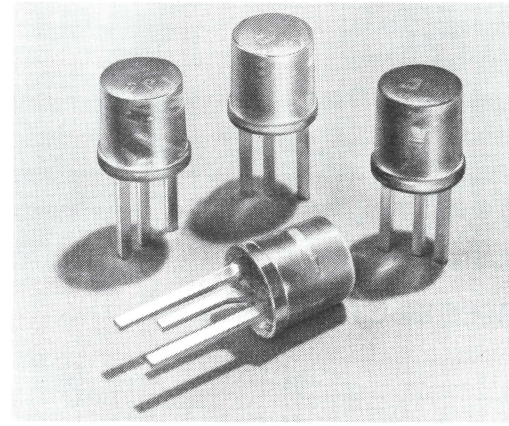
HEWLETT PACKARD

T-2 (6 mm) Incandescent Alternative LED Lamps

High Efficiency Red HLMP-A200
Yellow HLMP-A300
High Performance Green HLMP-A500

Features

- FOUR LED CHIPS PER LAMP
- WIDE RADIATION PATTERN
  $2\theta_{1/2}$ = 120° typ.
- HIGH LIGHT OUTPUT
- NON-DIFFUSED
- 3 COLORS
- POWER SAVING DESIGN



Advantages Over Incandescent Lamps

- MTBF IN EXCESS OF 5,000,000 HOURS
- SOCKETS NOT NEEDED
- MECHANICALLY RUGGED PACKAGE
- LOW POWER CONSUMPTION

Applications

- ALTERNATIVE TO INCANDESCENT LAMPS
- LIGHTED SWITCHES
- BACKLIGHTING PANELS, LEGENDS

Description

The HLMP-A200/-A300/-A500 series of solid state lamps incorporates four LED chips in a single package to give bright uniform backlighting illumination to larger areas than is possible using conventional LED lamps. They provide a low power, long-life alternative to filtered incandescent lamps of similar size.

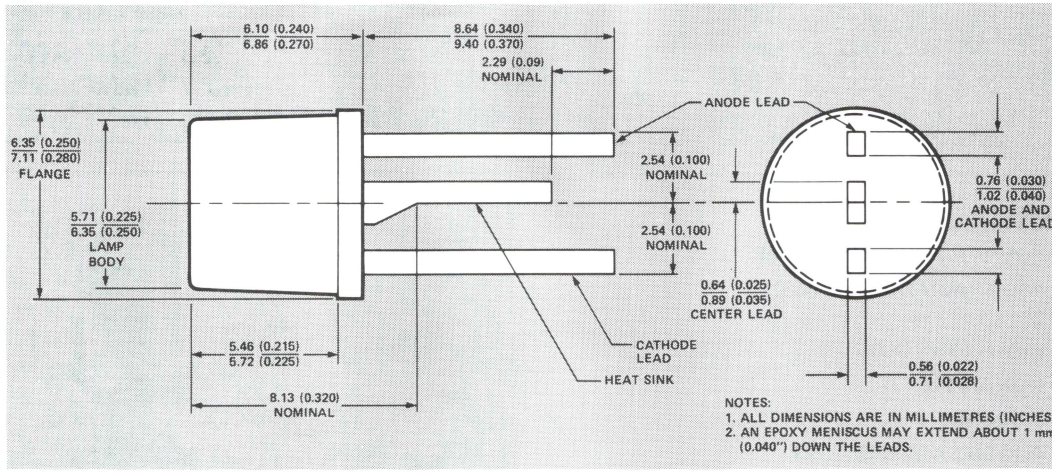
The devices have three leads: an anode, a cathode, and a center heat sink which allows operation at elevated temperatures. These non-diffused lamps are designed for backlighting applications where uniform illumination of a translucent surface is required. Typical applications are illuminated switch keycaps and backlighted front panel annunciator functions.

Axial Luminous Intensity and Viewing Angle

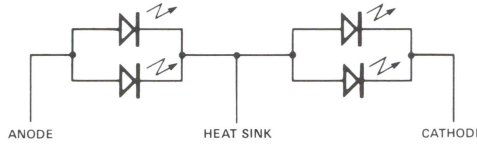
Color	Part Number HLMP-	Description	I_V (mcd) Min.	I_V (mcd) Typ.	ϕ_V (mlm) Typ.[1]	$2\theta_{1/2}$ Typ.[2]	Test Conditions
High Efficiency Red	A200	Backlighting Lamp General Purpose	22	40	180	114°	50 mA 25° C
Yellow	A300	Backlighting Lamp General Purpose	23	40	160	114°	50 mA 25° C
High Performance Green	A500	Backlighting Lamp General Purpose	27	40	225	124°	50 mA 25° C

Notes:
1. ϕ_V is the total luminous flux produced by the device, measured in millilumens.
2. $\theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the peak intensity.

Package Dimensions



Internal Circuit Diagram



THE CENTER HEAT SINK LEAD IS REQUIRED FOR EFFECTIVE HEAT DISSIPATION. NO EXTERNAL GROUND OR OTHER ELECTRICAL CONNECTION SHOULD BE MADE TO THE HEAT SINK LEAD.

Electrical/Optical Characteristics at $T_A = 25°C$

COMMON CHARACTERISTICS

		High Efficiency Red			Yellow			Green				
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
λ_{PEAK}	Peak Wavelength		635			583			565		nm	
λ_d	Dominant Wavelength[1]		626			585			569		nm	
η_V	Luminous Efficacy[2]		145			500			595		lumen /watt	
V_R	Reverse Breakdown Voltage	8.0			8.0			8.0			V	$I_R = 100\ \mu A$
V_F	Forward Voltage[3]	3.7	4.2	4.8	3.7	4.3	4.8	4.1	4.6	5.2	V	$I_F = 50$ mA
τ_S	Speed of Response		90			90			500		ns	
C	Capacitance		11			15			18		pF	$V_F = 0$, $f = 1$ MHz
θ_{JC}	Thermal Resistance[4]		60			60			60		°C/W	Junction to Pins (Total Package)

Notes:
1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
2. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$. Where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.
3. Designers should be aware that selection of current limiting resistors becomes critical in 5 volt applications.
4. The value $R_{\theta J\text{-}PIN} = 60°C/W$ is the combined thermal resistance, LED junction-to-pin, when both the heat sink and cathode leads are used for heat dissipation. For effective heat dissipation, it is recommended that both the heat sink and cathode leads have equivalent thermal resistance paths to ambient.

Absolute Maximum Ratings at $T_A = 25°C$

HIGH EFFICIENCY RED, YELLOW AND GREEN LAMPS

Parameter	High Efficiency Red HLMP-A200	Yellow HLMP-A300	Green HLMP-A500	Units
Peak Forward Current	180	150	180	mA
Average Forward Current[1]	50	50	50	mA
DC Current[2]	60	50	60	mA
Power Dissipation[2]	370	300	410	mW
Reverse Voltage (I_R = 100 μA)	8	8	8	V
Transient Forward Current[3] (10 μsec Pulse)	750	750	750	mA
Operating Temperature Range[2]	-20 to +95	-20 to +95	-20 to +95	°C
Storage Temperature Range	-55 to +100	-55 to +100	-55 to +100	
Lead Soldering Temperature (1.6 mm [0.063 in] from body)	260° C for 5 seconds			

Notes:
1. See Figure 2 to establish pulsed operating conditions.
2. Operation at high ambient temperatures will require current (power) derating per Figure 3.
3. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

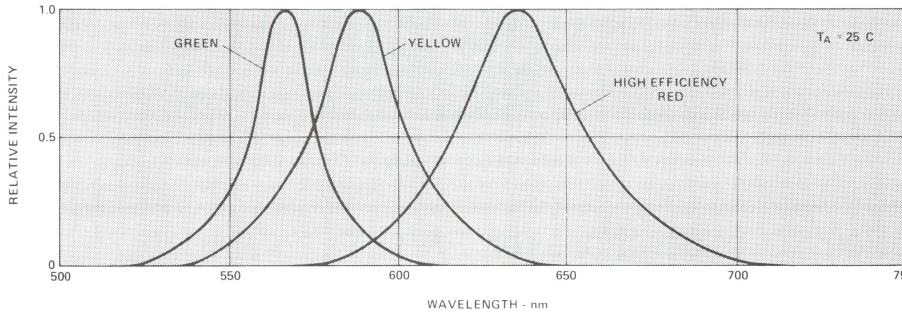


Figure 1. Relative Intensity vs. Wavelength

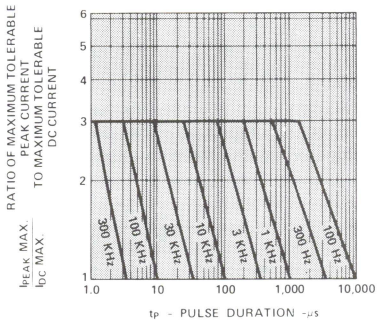


Figure 2. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings.)

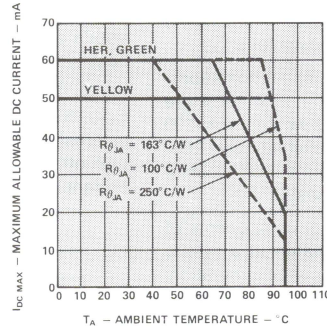


Figure 3. Maximum Allowable DC Current per Lamp vs. Ambient Temperature. Deratings are shown for Three Thermal Resistance Values, LED Junction to Ambient ($R_{\theta JA}$).

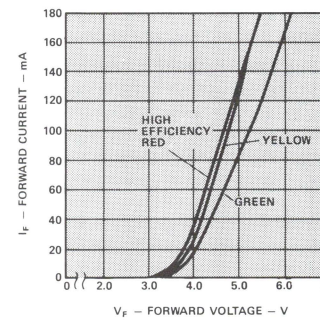


Figure 4. Typical Forward Current vs. Forward Voltage

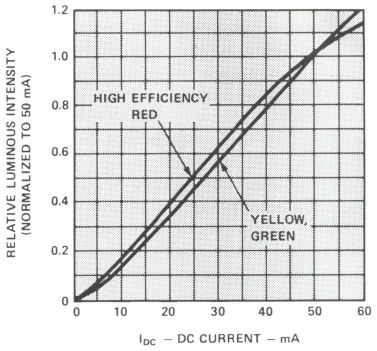


Figure 5. Relative Luminous Intensity vs. Forward Current

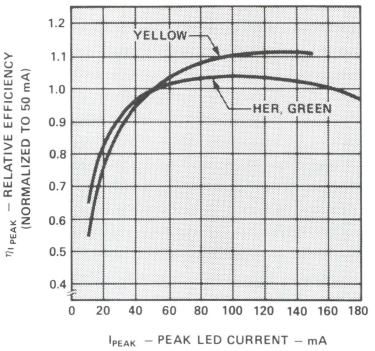


Figure 6. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak LED Current

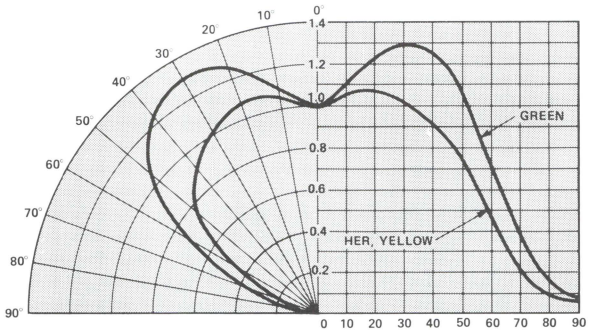


Figure 7. Far-Field Relative Luminous Intensity vs. Angular Displacement.

Operational Considerations for the HLMP-A200/-A300/-A500 Series of LED Lamps

The HLMP-A200/-A300/-A500 series of LED lamps was designed to combine the light-output of filtered incandescent lamps with the reliability and power savings of LEDs. These LEDs present a number of advantages over incandescent lamps in a wide variety of backlighting applications:

Long Life — When operated within data sheet conditions, LED lamps exhibit MTBFs over 5,000,000 hours. Miniature incandescent lamps typically have MTBFs varying from 500 to 25,000 hours. Due to the superior reliability of LEDs, they may be permanently mounted on circuit boards, eliminating sockets and their associated costs.

Rugged Package — Since all the internal components of an LED lamp are permanently encapsulated in a plastic package, they are extremely resistant to shock, vibration, and breakage.

Low Power — In many applications, these LED lamps provide the same light output as a filtered incandescent lamp, yet consume 50% to 75% less power. They therefore generate less heat, and require smaller power supplies.

ELECTRICAL CONSIDERATIONS

INTERNAL CIRCUIT — The HLMP-A200, -A300, and -A500 devices contain four LED chips wired in a "series-parallel" electrical configuration. There are two pairs of parallel-wired chips, with the two pairs wired in series. See Figure 8.

This electrical arrangement provides compatibility with low voltage systems, yet still allows operation at relatively low currents. The outer two leads of the lamp serve as the anode and cathode. The cathode lead also serves as a heat sink for two of the LED chips with the center lead providing a heat sink for the other two LED chips.

CAUTION: DO NOT connect the heat sink lead to any external electrical circuitry or ground. This could either turn off the LED chips or expose them to excessive drive current.

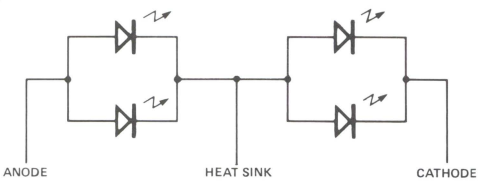


Figure 8. Internal Circuit Diagram

The typical forward voltage values, either scaled from Figure 4 or calculated from the model listed below, can be used to calculate the current limiting resistor value and typical power dissipation. Expected minimum and maximum forward voltages may be calculated from the following worst case models. These models can be used to calculate the maximum power dissipation as well as minimum and maximum forward currents for a given electrical design.

$V_F MIN = V_O MIN + I_F (R_S MIN)$
$V_F TYP = V_O TYP + I_F (R_S TYP)$
$V_F MAX = V_O MAX + I_F (R_S MAX)$
For: $I_F \geq 20$ mA

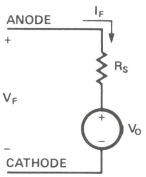


Figure 9. Electrical Model

The expected values for V_O and R_S are listed below in Table 1.

EXAMPLE — What is the expected minimum and maximum forward voltage for the HLMP-A200 operated at 60 mA?

$V_F MIN = 3.4 + (.060)(6)$
$= 3.76$

$V_F MAX = 3.8 + (.060)(20)$
$= 5.00$

DRIVING THE LAMP — Like other LED devices, this lamp is *current* driven, and drive circuits must be designed to prevent excessive current from flowing through the device.

The lamp has been designed for DC operation. Pulsed operation at average currents in the range of 40-60 mA is allowable but will not increase the light output significantly as compared to the same DC current.

CONSTANT-CURRENT DRIVERS — The use of transistors or certain driver ICs which have constant-current outputs to power the lamp is recommended. Drive configurations such as these provide high immunity to power-supply voltage variation and easy interface to logic circuits. Examples of such drive circuits can be found in Hewlett-Packard's *Fiber Optics Applications Manual* (HPBK-2000), Section 2.4.

RESISTIVE CURRENT-LIMITING — The simplest method of driving the lamp is to operate it with a series resistor from a fixed voltage supply. Since this drive circuit is most susceptible to variations in both the power supply voltage and the LED's forward voltage, a worst-case design example is shown.

EXAMPLE — What is the resistor value needed to run the HLMP-A200 at the maximum DC current at 45° C using a 6.3 ± 5% DC supply?

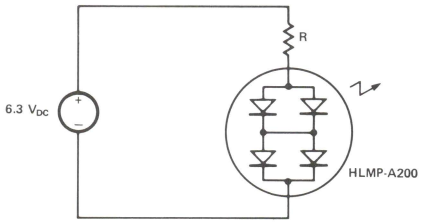


Figure 10. Circuit to Operate the Lamp at 6.3 V DC

Referring to Figure 3, in a typical mounting scheme with θ_{JA} = 163° C/W, the maximum DC current is 60 mA at 45° C.

$$R = \frac{V_S - V_O}{I_F} - R_S$$

Where V_S = power supply voltage
V_O = device voltage intercept from model
I_F = desired forward current
R_S = device internal resistance from model

$$R = \frac{(6.3)(1.05) - 3.4}{(.060)} - 6$$
$= 48$ ohms
$= 51$ ohms (next higher standard 5% value)

Resistor power dissipation:
$P = I^2 R$
$= (.060)^2 (51)$
$= .184$ Watt
= ¼ Watt resistor (next higher standard value)

Using this 51 ± 5% ohm resistor and a 6.3 V ± 5% power supply, what is the expected minimum, typical, and maximum forward current?

$$I_F = \frac{(V_S - V_O)}{(R + R_S)}$$

Where V_S = power supply voltage
V_O = device voltage intercept from model
R = external current limiting resistor
R_S = device internal resistance from model

$$I_F MIN = \frac{(6.3)(.95) - 3.8}{(51)(1.05) + 20}$$
$= 21$ mA

$$I_F TYP = \frac{6.3 - 3.6}{51 + 12}$$
$= 43$ mA

$$I_F MAX = \frac{(6.3)(1.05) - 3.4}{(51)(.95) + 6}$$
$= 59$ mA

Table 1. Expected typical and worst case values of V_O and R_S

Color	P/N HLMP	V_OMIN	R_SMIN	V_OTYP	R_STYP	V_OMAX	R_SMAX
HER	A200	3.4 V	6 ohms	3.6 V	12 ohms	3.8 V	20 ohms
Yellow	A300	3.4 V	6 ohms	3.8 V	10 ohms	3.9 V	18 ohms
Green	A500	3.7 V	8 ohms	3.8 V	16 ohms	4.1 V	22 ohms

MECHANICAL & HANDLING CONSIDERATIONS

LEAD CONSTRUCTION — Heavy copper leads were designed into this series of LED lamps to effectively dissipate the heat generated by the four LED chips. Because the leads are so rigid, care must be taken that the leads are NOT bent in such a way that cracking of the encapsulating epoxy occurs.

LEAD PLATING — Lamp leads in this series are silver plated. In order to prevent lead tarnishing, finger cots should be worn whenever handling the devices.

SOLDERING — These LED lamps can withstand wave soldering conditions as outlined in Application Note 1027, "Soldering LED Components." Solder temperatures of 260° C for up to 5 seconds will not damage these devices.

THERMAL

Although LED lamps are extremely reliable within the normal operating temperature range, problems may be encountered at very high temperatures. Specifically, catastrophic failures can occur when the LED junction temperature exceeds 110° C. Several guidelines have been incorporated into this data sheet to prevent such operation.

MOUNTING THE LAMP — The Cathode and Heat Sink (center) leads provide the thermal paths for heat generated at the LED junctions to leave the package. Approximately ½ the total package power is dissipated by each of these two leads. For best results, all three leads should be soldered to a printed-circuit board. It is recommended that both the heat sink and cathode leads be soldered to small (⅜" x ⅜") metalized areas on the board in the vicinity of the lamp, particularly if a number of lamps are placed close together.

In most cases, forced air circulation around the lamp is not necessary. It is important that the natural convection of air around the device is not obstructed. Efficient heat sinking of this sort will allow operation of the lamp at higher ambient temperatures without exceeding the 110° C maximum LED junction temperature.

DETERMINING THE LED JUNCTION TEMPERATURE — The LED junction temperature is difficult to measure directly, but it can be computed if the lamp's lead temperature and its thermal resistance (junction to pin) are known.

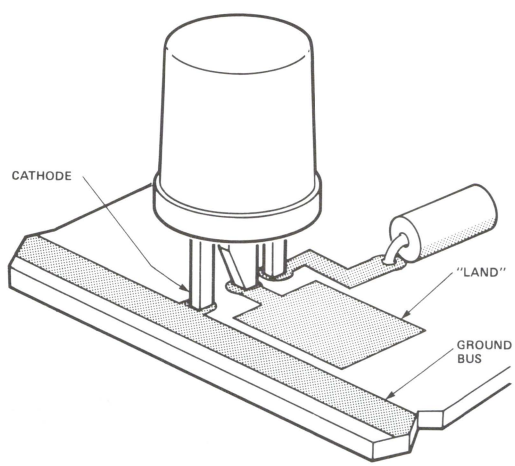


Figure 11. Use of Metalized Printed Circuit Board to Heat Sink the Lamp

EXAMPLE — Is it safe to operate a HLMP-A200 device at 50 mA forward current if both the cathode and heat sink lead temperatures are 65° C?

Maximum power dissipated by the lamp:

$$P = (I_F)(V_F)$$
$$= (0.050\ A)(4.8\ V)$$
$$= 0.240\ W$$

Temperature difference between the LED junction and the leads:

$$\Delta T = (\theta_{J\text{-}PIN})(P)$$
$$= (60°\ C/W)(0.240\ W)$$
$$= 14°\ C$$

Maximum LED junction temperature:

$$T_g = T_{PIN} + \Delta T$$
$$= 65°\ C + 14°\ C$$
$$= 79°\ C$$
$$< 110°\ C, \text{ therefore safe}$$

In situations where the worst-case *lead* temperature is unavailable, θ_{JA} (the thermal resistance, junction to *ambient*) may be used to determine the LED junction temperature directly from the ambient temperature. This thermal resistance will be highly dependent on the physical configuration of the equipment in which the lamp is mounted.

Figure 3 shows the maximum allowable drive current vs. ambient temperature for several different values of θ_{JA}. The worst case value of 250° C/Watt roughly corresponds to mounting the LED in a very small, enclosed housing without efficient heat sinking (such as in a pushbutton switch). The typical value of 163° C/W might be encountered if the LED is mounted with other components on a PC board in a naturally-convected piece of equipment. The best-case value of 100° C/W may be achieved if the lamp is soldered to a PC board with large metal "lands" connected to the leads and moderate airflow around the device. As shown in this figure, the full-power operating temperature range is extended as the thermal resistance is lowered.

OPTICAL

The radiation pattern for this series of lamps (shown in Figure 7) has been specifically tailored for even illumination of flat translucent surfaces. In order to prevent objectionable "hot-spots" on the surface to be illuminated, the luminous intensity is designed to be greater off-axis than on-axis. At more than 50° off-axis, the light output rapidly drops off so as to minimize light loss out the sides and back of the lamp.

The relative positioning of the lamp and the surface to be illuminated will need to be optimized for the designer's particular application. Placing the lamp in close proximity to the legend results in bright illumination of a small area; pulling the lamp farther back illuminates larger areas with lower brightness.

It may be desirable to mount reflective white baffles around the lamp to redirect some of the light emerging at wide angles onto the legend. Such baffles are also effective at eliminating "cross-talk", a situation in which light from one lamp partially illuminates an adjacent legend. Care should be taken to insure that such baffles do not completely obstruct air flow around the device.

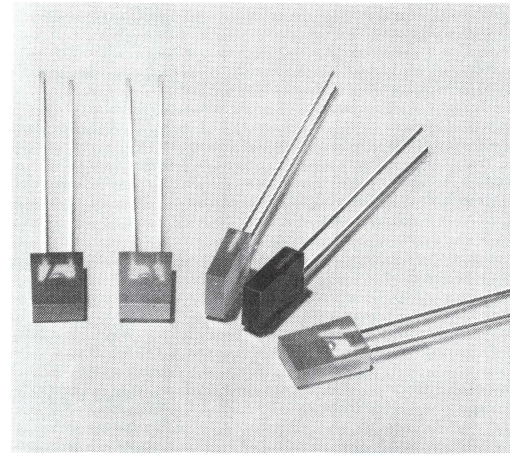
HEWLETT PACKARD

2 mm x 5 mm RECTANGULAR LAMPS

HIGH EFFICIENCY RED HLMP-S200 SERIES
YELLOW HLMP-S300 SERIES
ORANGE HLMP-S400 SERIES
HIGH PERFORMANCE GREEN HLMP-S500 SERIES

Features

- **RECTANGULAR LIGHT EMITTING SURFACE**
- **EXCELLENT FOR FLUSH MOUNTING ON PANELS**
- **CHOICE OF 4 BRIGHT COLORS**
- **LONG LIFE: SOLID STATE RELIABILITY**
- **EXCELLENT UNIFORMITY OF LIGHT OUTPUT**

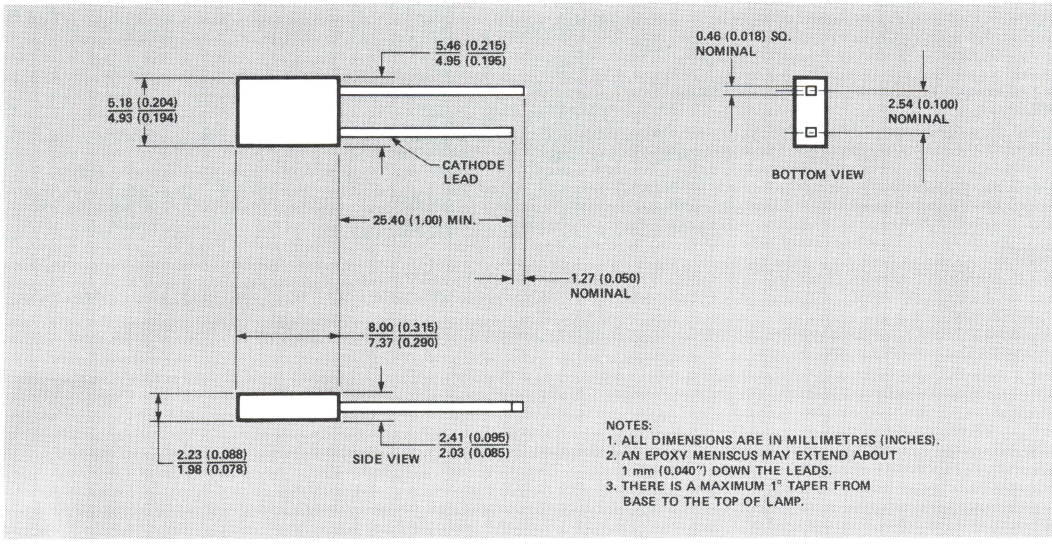


Description

The HLMP-S200, -S300, -S400, -S500 are epoxy encapsulated lamps in rectangular packages which are easily stacked in arrays or used for discreet front panel indicators. Contrast and light uniformity are enhanced by a special epoxy diffusion and tinting process.

In addition to the standard high efficiency red, yellow, and high performance green colors, this product comes in Orange for greater flexibility in human factors design.

Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1 mm (0.040") DOWN THE LEADS.
3. THERE IS A MAXIMUM 1° TAPER FROM BASE TO THE TOP OF LAMP.

SOLID STATE LAMPS

Electrical/Optical Characteristics at $T_A = 25°C$

Symbol	Description	Device HLMP-	Min.	Typ.	Max.	Units	Test Conditions
I_V	Luminous Intensity	High Efficiency Red					
		S200	2.1	3.5			
		S201	3.4	4.8			
		Orange					
		S400	2.1	3.5			
		S401	3.4	4.8		mcd	I_F = 20 mA
		Yellow					
		S300	1.4	2.1			
		S301	2.2	3.5			
		Green					
		S500	2.6	4.0			
		S501	4.1	5.8			
$2\Theta 1/2$	Included Angle Between Half Luminous Intensity Points	All		110		Deg.	I_F = 20 mA See Note 1
λ_{PEAK}	Peak Wavelength	High Efficiency Red		635			
		Orange		612		nm	Measurement at Peak
		Yellow		583			
		Green		565			
λ_d	Dominant Wavelength	High Efficiency Red		626			
		Orange		603		nm	See Note 2
		Yellow		585			
		Green		569			
τ_S	Speed of Response	High Efficiency Red		350			
		Orange		350		ns	
		Yellow		390			
		Green		870			
C	Capacitance	High Efficiency Red		11			
		Orange		4		pF	V_F = 0; f = 1 MHz
		Yellow		15			
		Green		18			
θ_{JC}	Thermal Resistance	All		120		°C/W	Junction to Cathode Lead at Seating Plane
V_F	Forward Voltage	HER/Orange	1.5	2.2	3.0		
		Yellow	1.5	2.2	3.0	V	I_F = 20 mA
		Green	1.5	2.3	3.0		
V_R	Reverse Breakdown Volt.	All	5.0			V	I_R = 100 μA
η_V	Luminous Efficacy	High Efficiency Red		145			
		Orange		262		$\frac{\text{lumens}}{\text{Watt}}$	See Note 3
		Yellow		500			
		Green		595			

NOTES:

1. $\Theta 1/2$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	High Efficiency Red/ Orange	Yellow	Green	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Transient Forward Current[4] (10 μsec Pulse)	500			mA
Operating Temperature Range	-55 to +100	-55 to +100	-20 to +85	°C
Storage Temperature Range			-55 to +100	
Lead Soldering Temperature [1.6 mm (0.063 in.) below seating plane]	260° C for 5 seconds			

Notes:
1. See Figure 5 to establish pulsed operating conditions.
2. For Red, Orange, and Green series derate linearly from 50°C at 0.5 mA/°C. For Yellow series derate linearly from 50°C at 0.34 mA/°C.
3. For Red, Orange, and Green series derate power linearly from 25°C at 1.6 mW/°C. For Yellow series derate power linearly from 50°C at 1.6 mW/°C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wire bond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

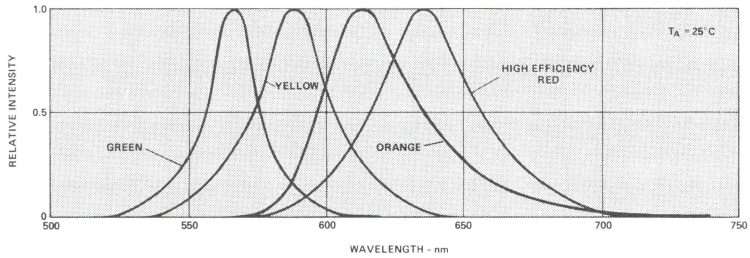


Figure 1. Relative Intensity vs. Wavelength.

High Efficiency Red, Orange, Yellow, and Green Rectangular Lamps

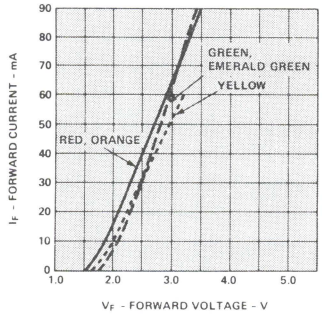


Figure 2. Forward Current vs. Forward Voltage Characteristics.

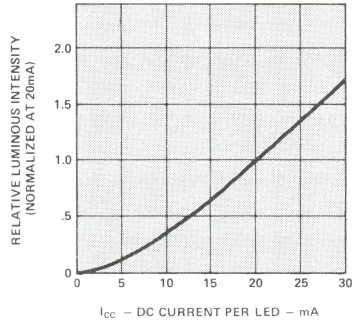


Figure 3. Relative Luminous Intensity vs. DC Forward Current.

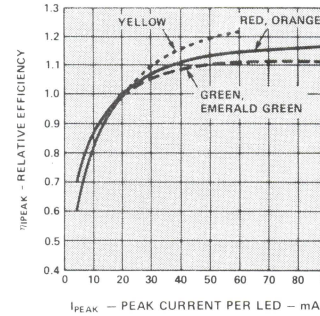


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. LED Peak Current.

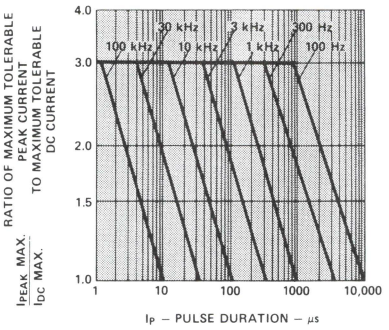


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings).

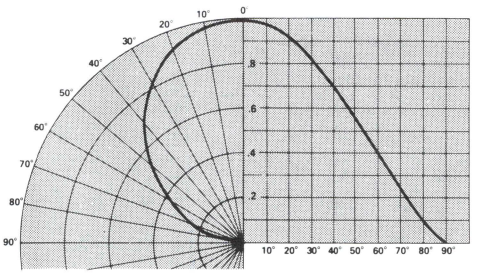


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

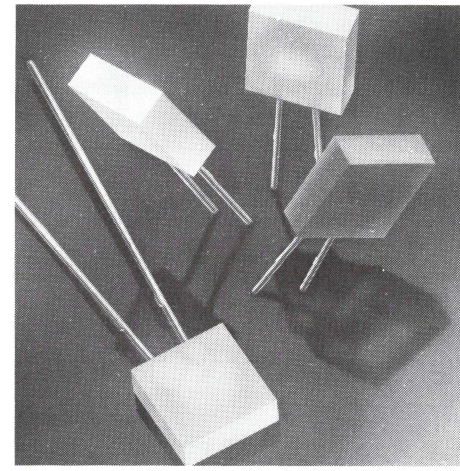
HEWLETT PACKARD

RECTANGULAR SOLID STATE LAMPS

HIGH EFFICIENCY RED HLMP-0300/0301
YELLOW HLMP-0400/0401
HIGH PERFORMANCE GREEN HLMP-0503/0504

Features

- **RECTANGULAR LIGHT EMITTING SURFACE**
- **FLAT HIGH STERANCE EMITTING SURFACE**
- **STACKABLE ON 2.54 MM (0.100 INCH) CENTERS**
- **IDEAL AS FLUSH MOUNTED PANEL INDICATORS**
- **IDEAL FOR BACKLIGHTING LEGENDS**
- **LONG LIFE: SOLID STATE RELIABILITY**
- **CHOICE OF 3 BRIGHT COLORS**
  HIGH EFFICIENCY RED
  YELLOW
  HIGH PERFORMANCE GREEN
- **IC COMPATIBLE/LOW CURRENT REQUIREMENTS**



Description

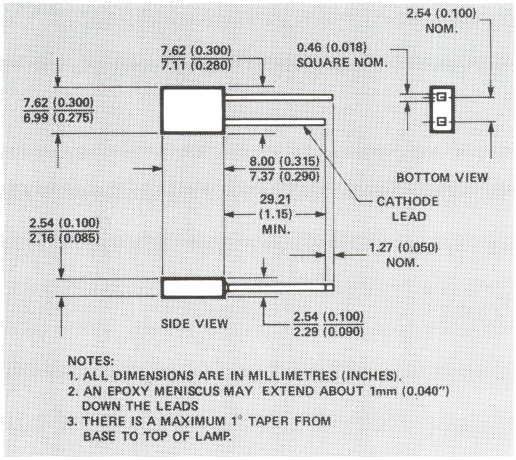
The HLMP-030X, -040X, -050X are solid state lamps encapsulated in a radial lead rectangular epoxy package. They utilize a tinted, diffused epoxy to provide high on-off contrast and a flat high intensity emitting surface. Borderless package design allows creation of uninterrupted light emitting areas.

The HLMP-0300 and -0301 have a high efficiency red GaAsP on GaP LED chip in a light red epoxy package. This lamp's efficiency is comparable to that of the GaP red, but extends to higher current levels.

The HLMP-0400 and -0401 provide a yellow GaAsP on GaP LED chip in a yellow epoxy package.

The HLMP-0503 and -0504 provide a green GaP LED chip in a green epoxy package.

Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1mm (0.040") DOWN THE LEADS
3. THERE IS A MAXIMUM 1° TAPER FROM BASE TO TOP OF LAMP.

Axial Luminous Intensity

Color	Part Number	I_V (mcd) @ 20 mA DC	
		Min.	Typ.
High Efficiency Red	HLMP-0300	1.0	2.5
	HLMP-0301	2.5	5.0
Yellow	HLMP-0400	1.5	2.5
	HLMP-0401	3.0	5.0
High Performance Green	HLMP-0503	1.5	2.5
	HLMP-0504	3.0	5.0

SOLID STATE LAMPS

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	HLMP-0300/-0301	HLMP-0400/0401	HLMP-0503/-0504	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Reverse Voltage (I_R = 100 μA)	5	5	5	V
Transient Forward Current[4] (10 μs Pulse)	500	500	500	mA
Operating Temperature Range	−55 to +100	−55 to +100	−20 to +100	°C
Storage Temperature Range			−55 to +100	
Lead Soldering Temperature [1.6 mm (0.063 in.) from body]	260° C for 5 seconds			

NOTES:

1. See Figure 5 to establish pulsed operating conditions.
2. For Red and Green Series derate linearly from 50° C at 0.5 mA/° C. For Yellow Series derate linearly from 50° C at 0.2 mA/° C.
3. For Red and Green series derate power linearly from 25° C at 1.8 mW/° C. For Yellow series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommedned that the device be operated at peak current beyond the peak forward current listed in the Absolute Maximum Ratings.

Electrical/Optical Characteristics at T_A=25°C

		HLMP-0300/-0301			HLMP-0400/-0401			HLMP-0503/-0504				
Symbol	Description	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
$2\Theta_{1/2}$	Included Angle Between Half Luminous Intensity Points		100			100			100		Deg.	Note 1. Figure 6.
λ_P	Peak Wavelength		635			583			565		nm	Measurement at Peak
λ_d	Dominant Wavelength		626			585			569		nm	Note 2
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth		40			36			28		nm	
τ_s	Speed of Response		90			90			500		ns	
C	Capacitance		16			18			18		pF	V_F = 0; f = 1 MHz
Θ_{JC}	Thermal Resistance		120			120			120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	1.6	2.2	3.0	1.6	2.2	3.0	1.6	2.3	3.0	V	I_F = 20 mA Figure 2.
V_R	Reverse Breakdown Voltage	5.0			5.0			5.0			V	I_R = 100 μA
η_V	Luminous Efficacy		145			500			595		lm/W	Note 3

NOTES:

1. $\Theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

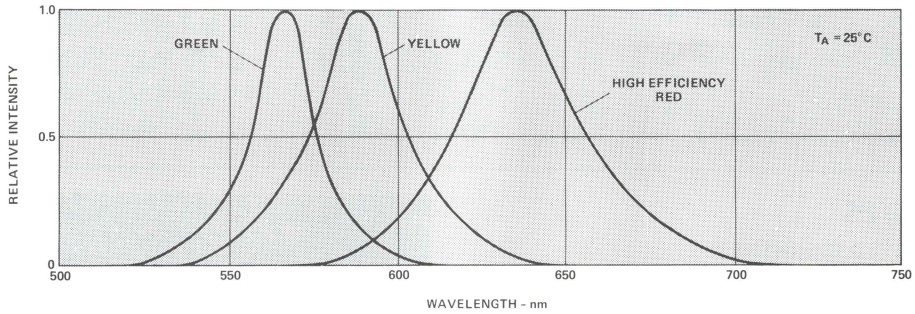


Figure 1. Relative Intensity vs. Wavelength.

High Efficiency Red, Yellow and Green Rectangular Lamps

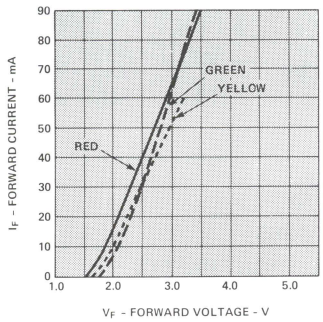


Figure 2. Forward Current vs. Forward Voltage.

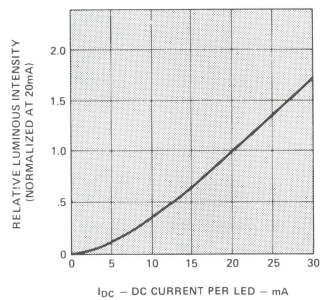


Figure 3. Relative Luminous Intensity vs. Forward Current.

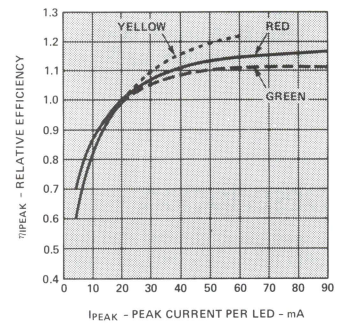


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

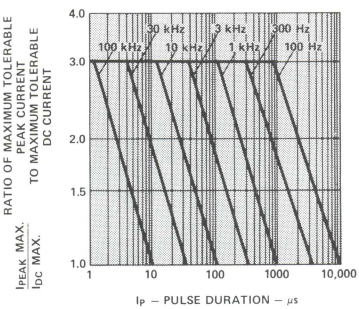


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings.)

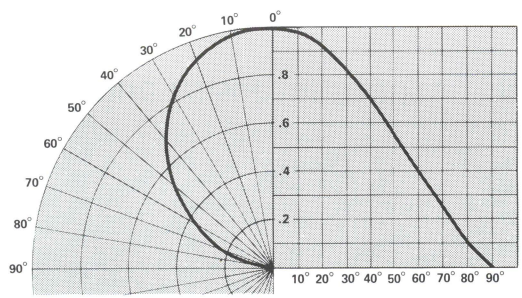


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

SOLID STATE LAMPS

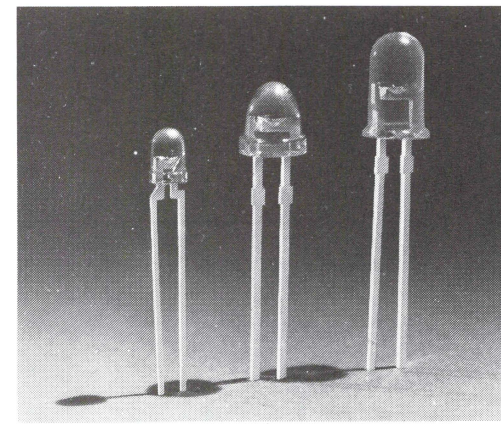
HEWLETT PACKARD

ULTRA-BRIGHT LED LAMP SERIES

T-1 3/4 HLMP-3750,-3850,-3950
T-1 3/4 LOW PROFILE HLMP-3390,-3490,-3590
T-1 HLMP-1340,-1440,-1540

Features

- **IMPROVED BRIGHTNESS**
- **IMPROVED COLOR PERFORMANCE**
- **AVAILABLE IN POPULAR T-1 and T-1 3/4 PACKAGES**
- **NEW STURDY LEADS**
- **IC COMPATIBLE/LOW CURRENT CAPABILITY**
- **RELIABLE AND RUGGED**
- **CHOICE OF 3 BRIGHT COLORS**
  High Efficiency Red
  High Brightness Yellow
  High Performance Green



Description

These clear, non-diffused lamps out perform conventional LED lamps. By utilizing new higher intensity material, we achieve superior product performance.

The HLMP-3750/-3390/-1340 Series Lamps are Gallium Arsenide Phosphide on Gallium Phosphide red light emitting diodes. The HLMP-3850/-3490/-1440 Series are Gallium Arsenide Phosphide on Gallium Phosphide yellow light emitting diodes. The HLMP-3950/-3590/-1540 Series lamps are Gallium Phosphide green light emitting diodes.

Applications

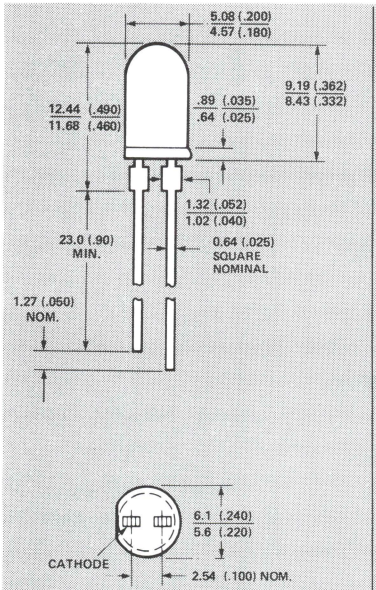
- **LIGHTED SWITCHES**
- **BACKLIGHTING FRONT PANELS**
- **LIGHT PIPE SOURCES**
- **KEYBOARD INDICATORS**

Axial Luminous Intensity and Viewing Angle @ 25°C

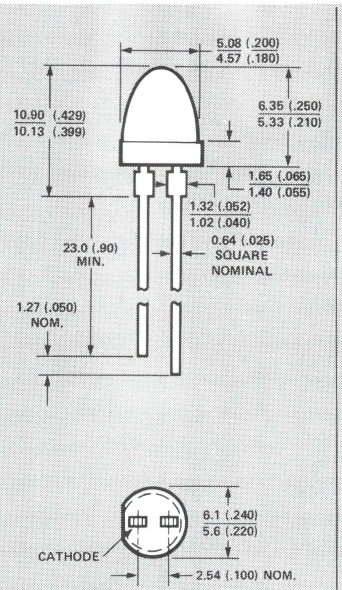
Part Number HLMP-	Package Description	Color	I_V (mcd) @ 20 mA DC		2Θ 1/2 Note 1.	Package Outline
			Min.	Typ.		
3750	T-1 3/4	HER	80	125	24°	A
3850		Yellow	80	140	24°	A
3950		Green	80	120	24°	A
3390	T-1 3/4 Low Profile	HER	35	55	32°	B
3490		Yellow	35	55	32°	B
3590		Green	35	55	32°	B
1340	T-1	HER	24	35	45°	C
1440		Yellow	24	35	45°	C
1540		Green	24	35	45°	C

NOTE:
1. Θ1/2 is the typical off-axis angle at which the luminous intensity is half the axial luminous intensity.

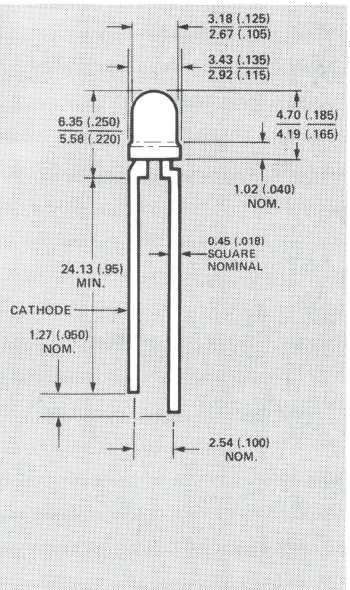
Package Dimensions



PACKAGE OUTLINE "A"
HLMP-3750, 3850, 3950



PACKAGE OUTLINE "B"
HLMP-3390, 3490, 3590



PACKAGE OUTLINE "C"
HLMP-1340, 1440, 1540

NOTES:
1. All dimensions are in millimeters (inches).
2. An epoxy meniscus may extend about 1mm (0.40") down the leads.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	Red	Yellow	Green	Units
Peak Forward Current	90	60	90	mA
Average Forward Current[1]	25	20	25	mA
DC Current[2]	30	20	30	mA
Power Dissipation[3]	135	85	135	mW
Transient Forward Current[4] (10 μsec pulse)	500	500	500	mA
Reverse Voltage (I_R = 100 μA)	5	5	5	V
Operating Temperature Range	-55 to +100	-55 to +100	-20 to +100	°C
Storage Temperature Range			-55 to +100	
Lead Soldering Temperature (1.6 mm (0.063 in.) from body)	260° C for 5 seconds			

NOTES:
1. See Figure 2 to establish pulsed operating conditions.
2. For Red and Green series derate linearly from 50° C at 0.5 mA/° C. For Yellow series derate linearly from 50° C at 0.2 mA/° C.
3. For Red and Green series derate power linearly from 25° C at 1.8 mW/° C. For Yellow series derate power linearly from 50° C at 1.6 mW/° C.
4. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

Electrical/Optical Characteristics at $T_A = 25°C$

Symbol	Description	T-1 3/4	T-1 3/4 Low Dome	T-1	Min.	Typ.	Max.	Units	Test Conditions
λ_{PEAK}	Peak Wavelength	3750 3850 3950	3390 3490 3590	1340 1440 1540		635 583 565		nm	Measurement at peak
λ_d	Dominant Wavelength	3750 3850 3950	3390 3490 3590	1340 1440 1540		626 585 569		nm	Note 1
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth	3750 3850 3950	3390 3490 3590	1340 1440 1540		40 36 28		nm	
τ_s	Speed of Response	3750 3850 3950	3390 3490 3590	1340 1440 1540		90 90 500		ns	
C	Capacitance	3750 3850 3950	3390 3490 3590	1340 1440 1540		11 15 18		pF	$V_F = 0$; f = 1 MHz
θ_{JC}	Thermal Resistance	3750 3850 3950	3390 3490 3590	 1340 1440 1540		95 95 95 120 120 120		°C/W	Junction to Cathode Lead
V_F	Forward Voltage	3750 3850 3950	3390 3490 3590	1340 1440 1540	1.5 1.5 1.5	2.2 2.2 2.3	3.0 3.0 3.0	V	$I_F = 20$ mA (Figure 3)
V_R	Reverse Breakdown Voltage	3750 3850 3950	3390 3490 3590	1340 1440 1540	5.0			V	$I_F = 100\ \mu A$
η_V	Luminous Efficacy	3750 3850 3950	3390 3490 3590	1340 1440 1540		145 500 595		$\frac{\text{lumens}}{\text{watt}}$	Note 2

NOTES:

1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
2. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_v/\eta_v$, where I_v is the luminous intensity in candelas and η_v is the luminous efficacy in lumens/watt.

Red, Yellow and Green

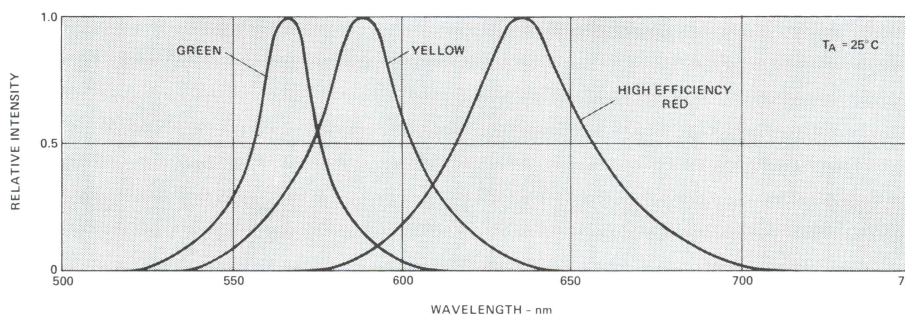


Figure 1. Relative Intensity vs. Wavelength.

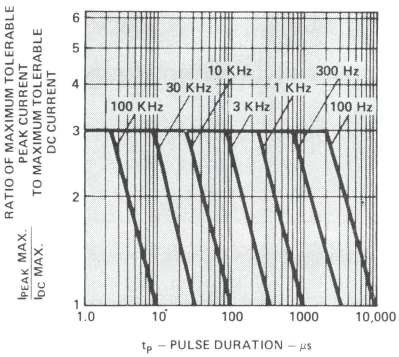


Figure 2. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings.)

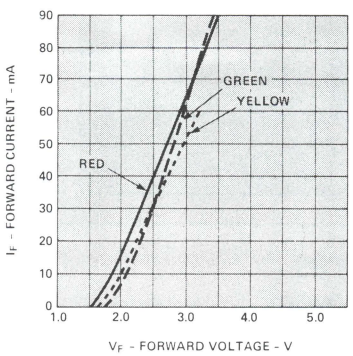


Figure 3. Forward Current vs. Forward Voltage.

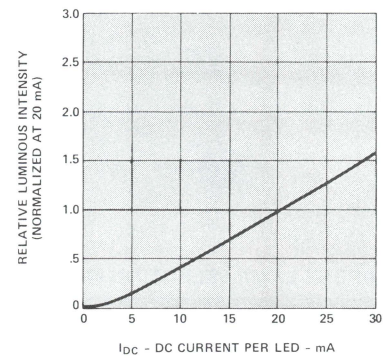


Figure 4. Relative Luminous Intensity vs. Forward Current.

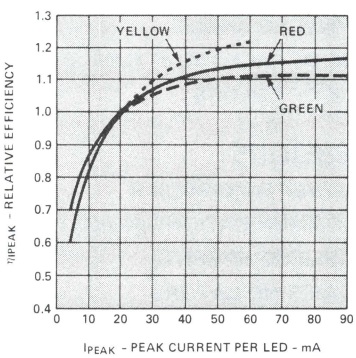


Figure 5. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

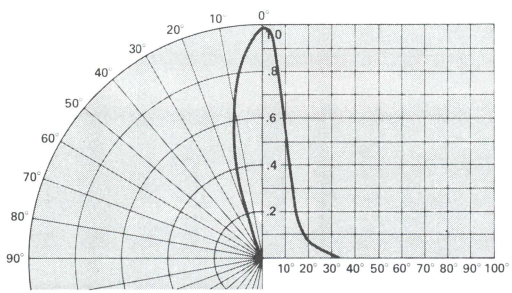


Figure 6. Relative Luminous Intensity vs. Angular Displacement. T-1 3/4 Lamp.

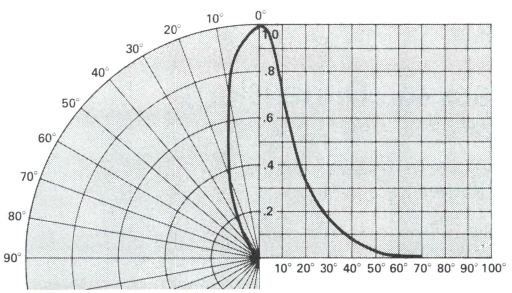


Figure 7. Relative Luminous Intensity vs. Angular Displacement. T-1 3/4 Low Profile Lamp.

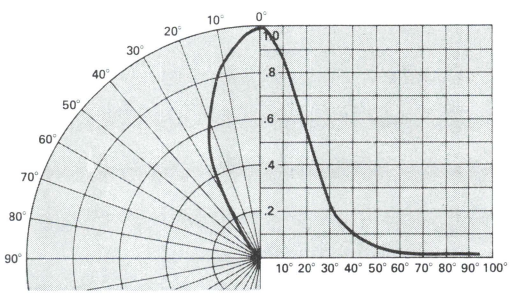


Figure 8. Relative Luminous Intensity vs. Angular Displacement. T-1 Lamp.

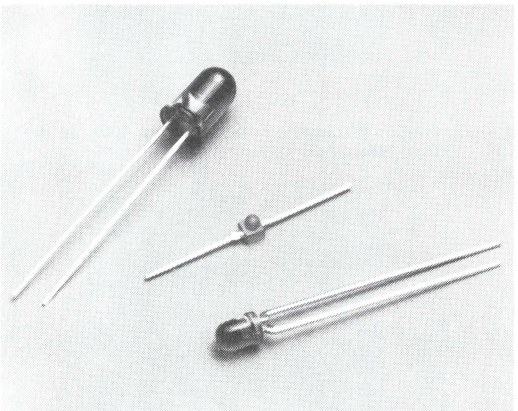
HEWLETT PACKARD

LOW CURRENT LED LAMP SERIES

T-1 3/4 (5mm) HLMP-4700, -4719, -4740
T-1 (3mm) HLMP-1700, -1719, -1790
SUBMINIATURE HLMP-7000, -7019, -7040

Features

- LOW POWER
- HIGH EFFICIENCY
- CMOS/MOS COMPATIBLE
- TTL COMPATIBLE
- WIDE VIEWING ANGLE
- CHOICE OF PACKAGE STYLES
- CHOICE OF COLORS



Applications

- LOW POWER DC CIRCUITS
- TELECOMMUNICATIONS INDICATORS
- PORTABLE EQUIPMENT
- KEYBOARD INDICATORS

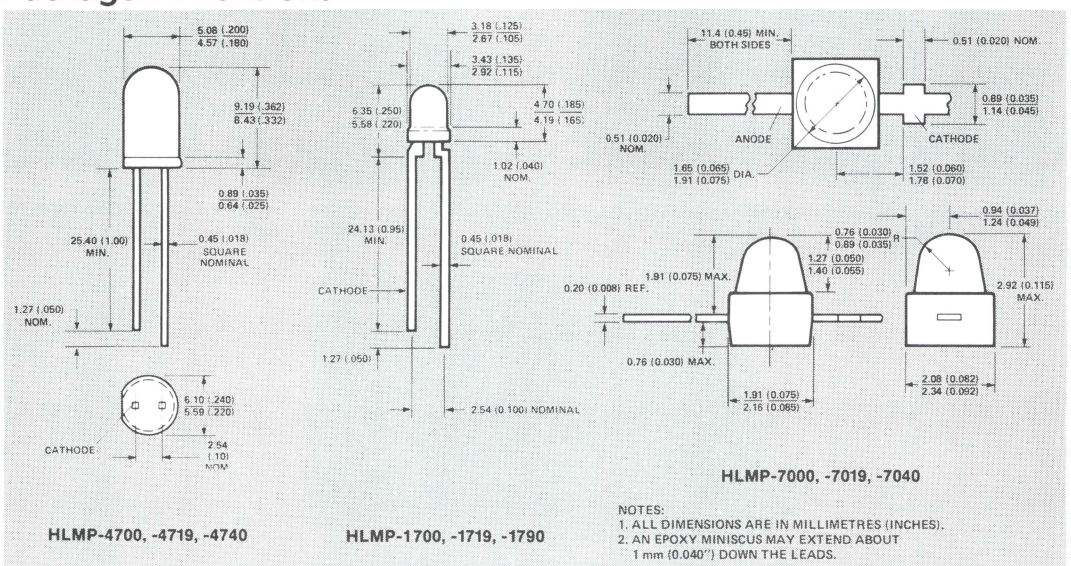
Description

These tinted diffused LED lamps were designed and optimized specifically for low DC current operation. Luminous intensity and forward voltage are tested at 2 mA to assure consistent brightness at TTL output current levels.

LOW CURRENT LAMP SELECTION GUIDE

Size	Color		
	Red HLMP-	Yellow HLMP-	Green HLMP-
T-1 3/4	4700	4719	4740
T-1	1700	1719	1790
Subminiature	7000	7019	7040

Package Dimensions



HLMP-4700, -4719, -4740

HLMP-1700, -1719, -1790

HLMP-7000, -7019, -7040

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MINISCUS MAY EXTEND ABOUT 1 mm (0.040") DOWN THE LEADS.

AXIAL LUMINOUS INTENSITY AND VIEWING ANGLE @ 25°C

Part Number HLMP-	Package Description	Color	I_V (mcd) @ 2 mA DC Min.	I_V (mcd) @ 2 mA DC Typ.	$2\Theta 1/2$[1]	Package Outline
-4700 -4719 -4740	T-1 3/4 Tinted Diffused	Red Yellow Green	1.2 1.2 1.2	2.0 1.8 1.8	50°	A
-1700 -1719 -1790	T-1 Tinted Diffused	Red Yellow Green	1.0 1.0 1.0	1.8 1.6 1.6	50°	B
-7000 -7019 -7040	Subminiature Tinted Diffused	Red Yellow Green	0.4 0.4 0.4	0.8 0.6 0.6	90°	C

Notes:
1. $\Theta 1/2$ is the typical off-axis angle at which the luminous intensity is half the axial luminous intensity.

Electrical/Optical Characteristics at $T_A = 25°C$

Symbol	Description	T-1 3/4	T-1	Subminiature	Min.	Typ.	Max.	Units	Test Condition
V_F	Forward Voltage	4700 4719 4740	1700 1719 1790	7000 7019 7040		1.8 1.9 1.8	2.2 2.7 2.2	V	2 mA
V_R	Reverse Breakdown Voltage	4700 4719 4740	1700 1719 1790	7000 7019 7040	5.0 5.0 5.0			V	$I_R = 50\ \mu A$
λ_D	Dominant Wavelength	4700 4719 4740	1700 1719 1790	7000 7019 7040		626 585 569		nm	Note 1
$\Delta\lambda 1/2$	Spectral Line Halfwidth	4700 4719 4740	1700 1719 1790	7000 7019 7040		40 36 28		nm	
τS	Speed of Response	4700 4719 4740	1700 1719 1790	7000 7019 7040		90 90 500		ns	
C	Capacitance	4700 4719 4740	1700 1719 1790	7000 7019 7040		11 15 18		pF	$V_F = 0$ f = 1 MHz
ΘJC	Thermal Resistance	4700 4719 4740	1700 1719 1790	7000 7019 7040		120 120 120		°C/W	Junction to Cathode lead
$\lambda PEAK$	Peak Wavelength	4700 4719 4740	1700 1719 1790	7000 7019 7040		635 583 565		nm	Measurement at peak
ηv	Luminous Efficacy	4700 4719 4740	1700 1719 1790	7000 7019 7040		145 500 595		$\frac{\text{Lumens}}{\text{Watt}}$	Note 2

Notes:
1. The dominant wavelength, λ_D, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
2. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_{v/\eta v}$, where I_v is the luminous intensity in candelas and ηv is the luminous efficacy in lumens/watt.

Absolute Maximum Ratings

Parameter	Maximum Rating		Units
Power Dissipation (Derate linearly from 92° C at 1.0 mA/° C)	Red Yellow Green	24 36 24	mW
DC and Peak Forward Current	7		mA
Transient Forward Current (10 μsec pulse)[1]	500		mA
Reverse Voltage (I_R = 50 μA)	5.0		V
Operating Temperature Range	Red/Yellow Green	-55°C to 100°C -20°C to 100°C	
Storage Temperature Range	-55°C to 100°C		
Lead Soldering Temperature (1.6 mm [0.063 in] from body)	260° C for 5 Seconds (T-1, T-1 3/4) 260° C for 3 Seconds (Subminiature)		

Notes:

1. The transient peak current is the maximum non-recurring peak current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

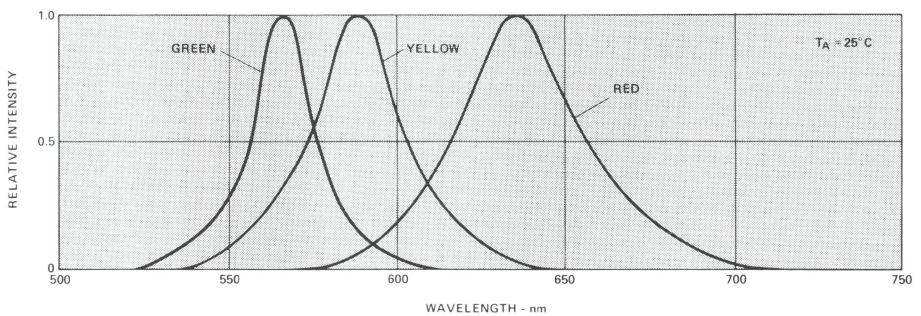


Figure 1. Relative Intensity vs. Wavelength

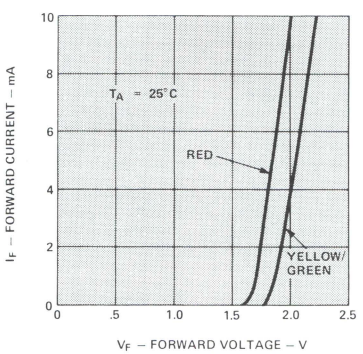


Figure 2. Forward Current vs. Forward Voltage

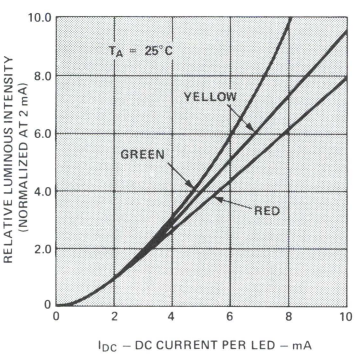


Figure 3. Relative Luminous Intensity vs. Forward Current

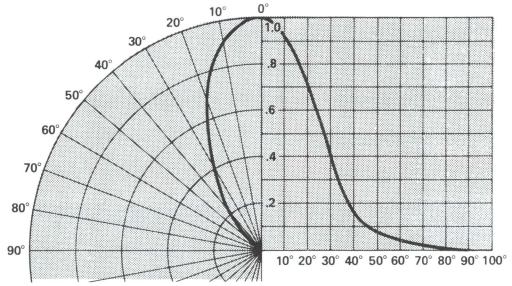


Figure 4. Relative Luminous Intensity vs. Angular Displacement for T-1 3/4 Lamp

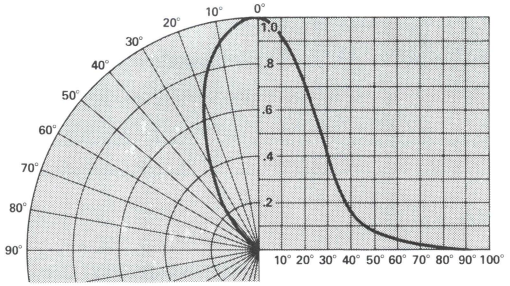


Figure 5. Relative Luminous Intensity vs. Angular Displacement for T-1 Lamp

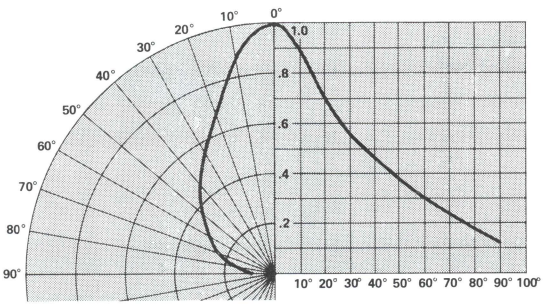


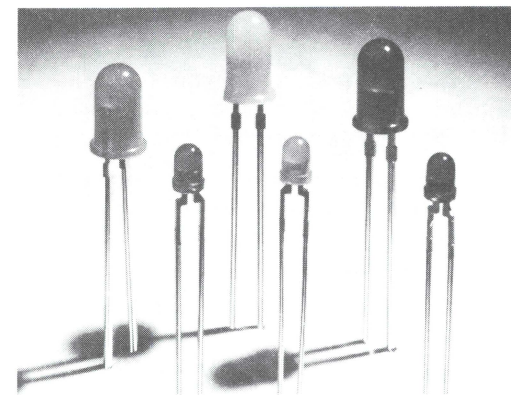
Figure 6. Relative Luminous Intensity vs. Angular Displacement for Subminiature Lamp

HEWLETT PACKARD

INTEGRATED RESISTOR LAMPS
5 Volt and 12 Volt Series in T-1 and T-1 3/4 Packages

Features

- **INTEGRAL CURRENT LIMITING RESISTOR**
- **TTL COMPATIBLE**
  Requires no External Current Limiter with 5 Volt/12 Volt Supply
- **COST EFFECTIVE**
  Saves Space and Resistor Cost
- **WIDE VIEWING ANGLE**
- **AVAILABLE IN ALL COLORS**
  Red, High Efficiency Red, Yellow and High Performance Green in T-1 and T-1 3/4 Packages



Description

The 5 volt and 12 volt series lamps contain an integral current limiting resistor in series with the LED. This allows the lamp to be driven from a 5 volt/12 volt source without an external current limiter. The red LEDs are made from GaAsP on a GaAs substrate. The High Efficiency Red and Yellow devices use GaAsP on a GaP substrate. The green devices use GaP on a GaP substrate. The diffused lamps provide a wide off-axis viewing angle.

The T-1 3/4 lamps are provided with sturdy leads suitable for wire wrap applications. The T-1 3/4 lamps may be front panel mounted by using the HLMP-0103 clip and ring.

Color	P/N HLMP-	Package	Operating Voltage	I_V mcd		2Θ 1/2[1]	Package Outline
				Min.	Typ.		
Red	1100	T-1 Tinted Diffused	5	0.8	1.5	60°	A
	1120	T-1 Untinted Diffused	5	0.8	1.5	60°	A
	3105	T-1 3/4 Tinted Diffused	5	1.0	2.0	60°	B
	3112		12	1.0	2.0	60°	B
High Efficiency Red	1600	T-1 Tinted Diffused	5	1.5	4.0	60°	A
	1601		12				
	3600	T-1 3/4 Tinted Diffused	5			60°	B
	3601		12				
Yellow	1620	T-1 Tinted Diffused	5	1.5	4.0	60°	A
	1621		12				
	3650	T-1 3/4 Tinted Diffused	5			60°	B
	3651		12				
High Performance Green	1640	T-1 Tinted Diffused	5	1.5	4.0	60°	A
	1641		12				
	3680	T-1 3/4 Tinted Diffused	5			60°	B
	3681		12				

Notes:
1. Θ1/2 is the off-axis angle at which the luminous intensity is half the axial luminous intensity.

Absolute Maximum Ratings at $T_A = 25°C$

	Red/HER/Yellow 5 Volt Lamps	Red/HER/Yellow 12 Volt Lamps	Green 5 Volt Lamps	Green 12 Volt Lamps
DC Forward Voltage ($T_A = 25°C$)	7.5 Volts[2]	15 Volts[3]	7.5 Volts[2]	15 Volts[3]
Reverse Voltage ($I_R = 100\ \mu A$)	5 Volts	5 Volts	5 Volts	5 Volts
Operating Temperature Range	−40° C to 85° C	−40° C to 85° C	−20° C to 85° C	−20° C to 85° C
Storage Temperature Range	−55° C to 100° C	−55° C to 100° C	−55° C to 100° C	−55° C to 100° C
Lead Soldering Temperature	260° C for 5 seconds			

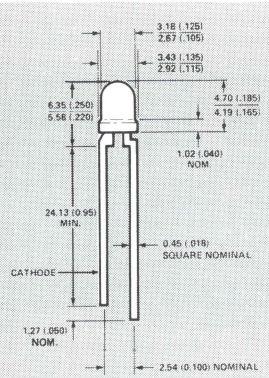
Notes:
2. Derate from $T_A = 50°C$ at 0.071V/° C, see Figure 3.
3. Derate from $T_A = 50°C$ at 0.086V/° C, see Figure 4.

Electrical/Optical Characteristics at $T_A = 25°C$

		Red			High Efficiency Red			Yellow			Green				
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
λ_{PEAK}	Peak Wavelength		655			635			583			565		nm	
λ_d	Dominant Wavelength		648			626			585			569		nm	Note 4
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth		24			40			36			28		nm	
θ_{JC}	Thermal Resistance		120			120			120			120		°C/W	Junction to Cathode Lead (Note 6)
θ_{JC}	Thermal Resistance		95			95			95			95		°C/W	Junction to Cathode Lead (Note 7)
I_F	Forward Current 12 V Devices		13	20		13	20		13	20		13	20	mA	$V_F = 12$ V
I_F	Forward Current 5 V Devices		13	20		10	15		10	15		12	15	mA	$V_F = 5$ V
η_V	Luminous Efficacy		65			145			500			595		lumen /watt	Note 5
V_R	Reverse Breakdown Voltage	5.0			5.0			5.0			5.0			V	$I_R = 100\ \mu A$

Notes:
4. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
5. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_V/\eta_V$. Where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.
6. For Figure A package type.
7. For Figure B package type.

Package Dimensions



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. AN EPOXY MENISCUS MAY EXTEND ABOUT 1mm (.040") DOWN THE LEADS.

Figure A. T-1 Package

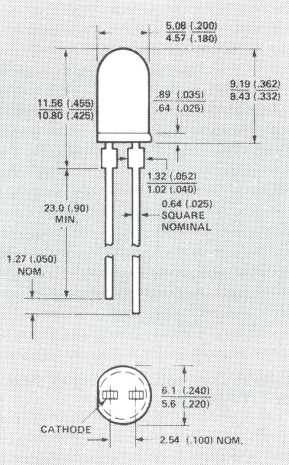


Figure B. T-1 3/4 Package

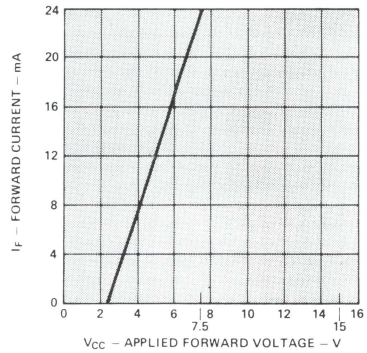


Figure 1. Forward Current vs. Applied Forward Voltage. 5 Volt Devices

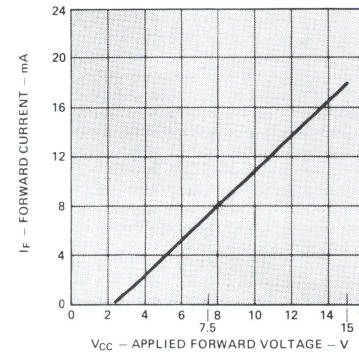


Figure 2. Forward Current vs. Applied Forward Voltage. 12 Volt Devices

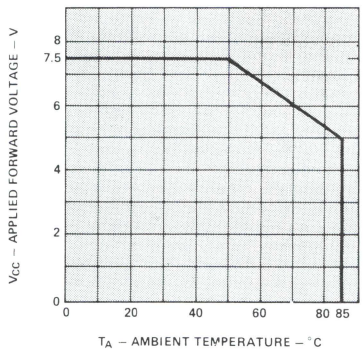


Figure 3. Maximum Allowed Applied Forward Voltage vs. Ambient Temperature $R\theta_{JA}$ = 175° C/W. 5 Volt Devices

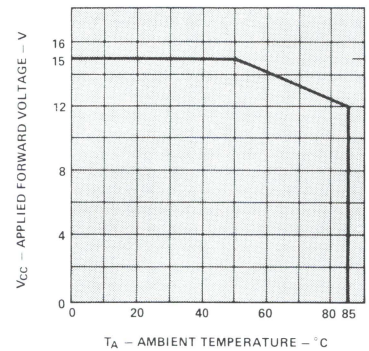


Figure 4. Maximum Allowed Applied Forward Voltage vs. Ambient Temperature $R\theta_{JA}$ = 175° C/W. 12 Volt Devices

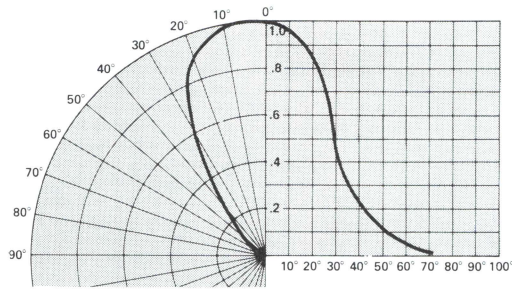


Figure 5. Relative Luminous Intensity vs. Angular Displacement for T-1 Package

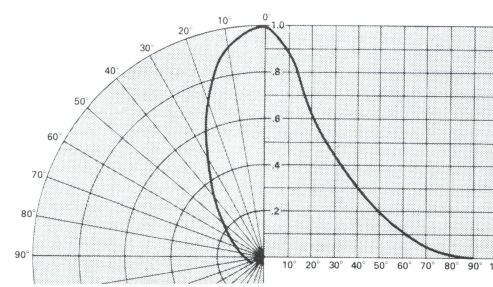


Figure 6. Relative Luminous Intensity vs. Angular Displacement for T-1 3/4 Package

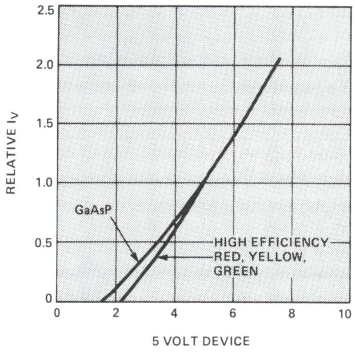


Figure 7. Relative Luminous Intensity vs. Applied Forward Voltage. 5 Volt Devices

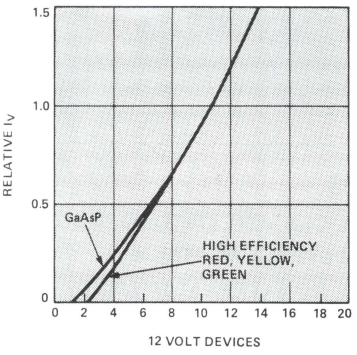


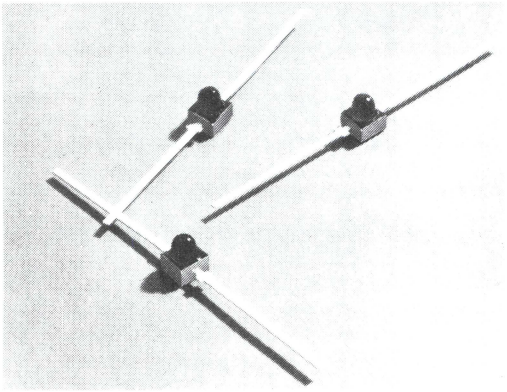
Figure 8. Relative Luminous Intensity vs. Applied Forward Voltage. 12 Volt Devices

HEWLETT PACKARD

SUBMINIATURE RESISTOR LAMPS 5 VOLT 4 mA AND 5 VOLT 10 mA SERIES

Features

- **INTEGRAL CURRENT LIMITING RESISTOR**
- **TTL AND LSTTL COMPATIBLE**
- **REQUIRES NO EXTERNAL RESISTOR WITH 5 VOLT SUPPLY**
- **SPACE SAVING SUBMINIATURE PACKAGE**
- **WIDE VIEWING ANGLE**
- **CHOICE OF CURRENT LEVEL, 4 mA or 10 mA**
- **AVAILABLE IN HIGH EFFICIENCY RED, YELLOW, AND GREEN**
- **IDEALLY SUITED FOR PORTABLE OR SPACE CONSTRAINED APPLICATIONS**



Description

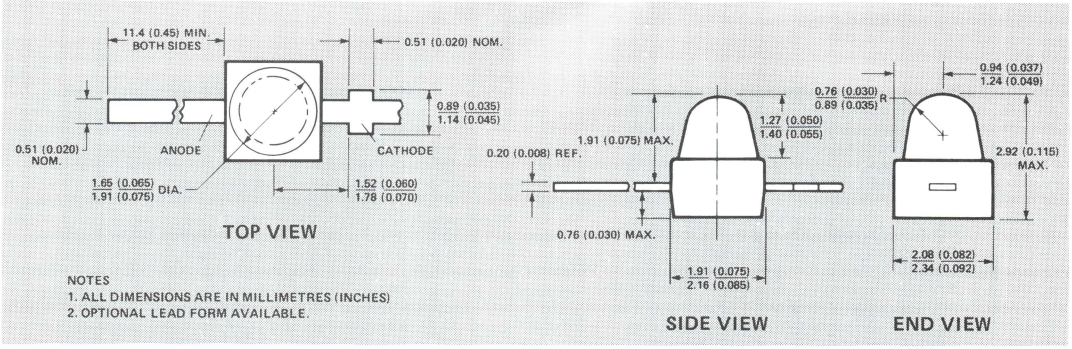
The subminiature resistor lamps contain an integral current limiting resistor in series with the LED. This allows the lamp to be driven from a 5 volt source without an external current limiter. The high efficiency red and yellow devices use GaAsP on a GaP substrate. The green devices use GaP on a GaP substrate. The tinted, diffused epoxy lens provides high on-off contrast and a wide viewing angle. The following special configurations are available on request:

1. Surface Mount Gull Wing Bend — Refer to the Surface Mount Gull Wing Data Sheet.
2. Tape and Reel Packaging
3. Special Lead Bending on 2.54 mm (0.100 in.) and 5.08 mm (0.200) in Centers

Device Selection Guide

	High Efficiency Red	Yellow	Green
5 Volt, 10 mA	HLMP-6600	HLMP-6700	HLMP-6800
5 Volt, 4 mA	HLMP-6620	HLMP-6720	HLMP-6820

Package Dimensions



NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES)
2. OPTIONAL LEAD FORM AVAILABLE.

Absolute Maximum Ratings at $T_A = 25°C$

	HLMP-6600/6620 6700/6720 High Efficiency Red/Yellow	HLMP-6800/6820 Green
DC Forward Voltage	6 Volts	6 Volts
Reverse Voltage ($I_R = 100\mu A$)	5 Volts	5 Volts
Operating Temperature Range	−40°C to 85°C	−20°C to 85°C
Storage Temperature Range	−55°C to 100°C	
Lead Soldering Temperature 1.6 mm (0.063 in.) From Body	260°C for 3 Seconds	

Electrical/Optical Characteristics at $T_A = 25°C$

		High Efficiency Red						Yellow						Green							
		HLMP-6600			HLMP-6620			HLMP-6700			HLMP-6720			HLMP-6800			HLMP-6820				
Symbol	Parameter	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Test Conditions
I_V	Axial Luminous Intensity	1.3	5.0		0.8	2.0		1.4	5.0		0.9	2.0		1.6	5.0		0.8	2.0		mcd	$V_F = 5$ Volts (See Figure 2)
$2\Theta_{1/2}$	Included Angle Between Half Luminous Intensity Points		90			90			90			90			90			90		Deg	Note 1 (See Figure 3
λ_{PEAK}	Peak Wavelength		635			635			583			583			565			565		nm	
λ_D	Dominant Wavelength		626			626			585			585			569			569		nm	Note 2
$\Delta\lambda_{1/2}$	Spectral Line Halfwidth		40			40			36			36			28			28		nm	
Θ_{JC}	Thermal Resistance		120			120			120			120			120			120		°C/W	Junction to Cathode Lead
I_F	Forward Current		9.6	13		3.5	5		9.6	13		3.5	5		9.6	13		3.5	5	mA	$V_F = 5$ Volts (See Figure 1)
V_R	Reverse Breakdown Voltage	5.0			5.0			5.0			5.0			5.0			5.0			V	$I_R = 100\ \mu A$
η_V	Luminous Efficacy		145			145			500			500			595			595		lm/w	Note 3

Notes:

1. $2\Theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Radiant intensity in watts/steradion, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

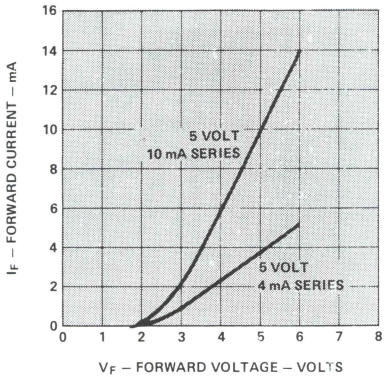


Figure 1. Forward Current vs. Forward Voltage.

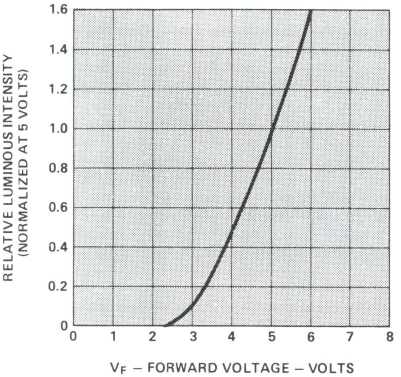


Figure 2. Relative Luminous Intensity vs. Forward Voltage.

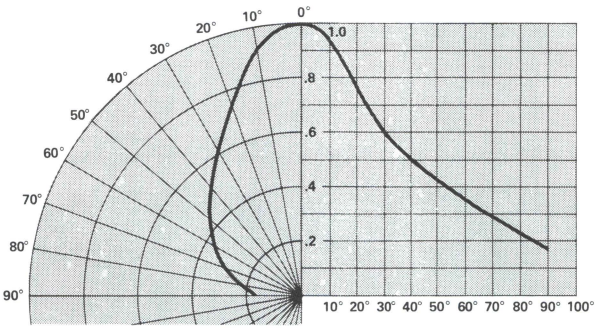


Figure 3. Relative Luminous Intensity vs. Angular Displacement.

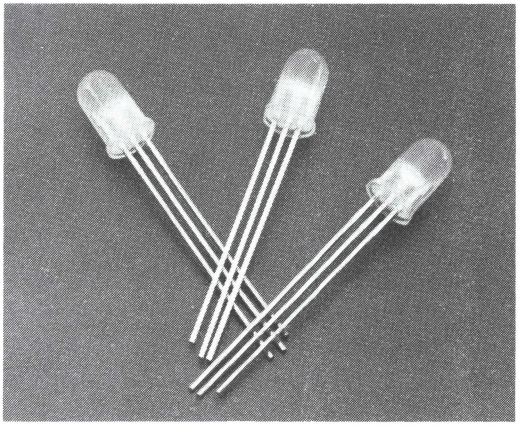
HEWLETT PACKARD

HIGH EFFICIENCY RED/T-1 3/4 (5 mm) HIGH PERFORMANCE GREEN BICOLOR SOLID STATE LAMP

HLMP-4000

Features:

- **TWO COLOR (RED, GREEN) OPERATION**
- **POPULAR T-1 3/4 PACKAGE**
- **3 LEADS WITH ONE COMMON CATHODE**
- **DIFFUSED, WIDE VISIBILITY LENS**
- **TTL COMPATIBLE**



Description

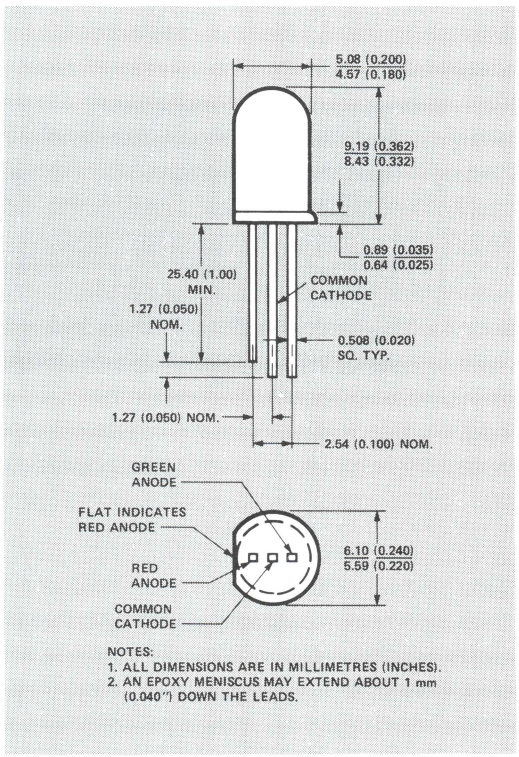
The T-1 3/4 HLMP-4000 lamp is a three leaded bicolor light source designed for a variety of applications where dual state illumination is required in the same package. There are two LED chips, high efficiency red (HER) and high performance green (Green), mounted on a central common cathode lead for maximum on-axis viewability. Colors between HER and Green can be generated by independently pulse width modulating the LED chips.

Absolute Maximum Ratings at $T_A = 25°C$

Parameter	High Efficiency Red/Green	Units
Peak Forward Current	90	mA
Average Forward Current[1](Total)	25	mA
DC Current[4] (Total)	30	mA
Power Dissipation[3,5](Total)	135	mW
Operating Temperature Range	-20 to +85	°C
Storage Temperature Range	-55 to +100	
Reverse Voltage (I_R = 100 μA)	5	V
Transient Forward Current[6] (10 μsec Pulse)	500	mA
Lead Soldering Temperature [1.6 mm (0.063 in.) below seating plane]	260° C for 5 seconds	

Notes:
1. See Figure 5 to establish pulsed operating conditions.
2. The combined simultaneous current must not exceed the maximum.
3. The combined simultaneous power must not exceed the maximum.
4. For HER and Green derate linearly from 50° C at 0.5 mA/° C.
5. For HER and Green derate linearly from 25° C at 1.8 mW/° C.
6. The transient peak current is the maximum non-recurring current that can be applied to the device without damaging the LED die and wirebond. It is not recommended that the device be operated at peak currents beyond the peak forward current listed in the Absolute Maximum Ratings.

Package Dimensions



SOLID STATE LAMPS

Electrical Characteristics at $T_A = 25°C$

Symbol	Parameters	Red			Green			Units	Test Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.		
I_V	Luminous Intensity	2.1	5		4.2	8		mcd	I_F = 10 mA
λ_{PEAK}	Peak Wavelength		635			565		nm	
λ_d	Dominant Wavelength		626			569			See Note 1
τ_S	Speed of Response		90			500		ns	
C	Capacitance		11			18		pF	V_F = 0, f = 1 MHz
V_F	Forward Voltage		2.1	2.5		2.3	2.7	V	I_F = 10 mA
V_R	Reverse Breakdown Voltage	5			5			V	I_R = 100 μA
θ_{JC}	Thermal Resistance		120		120			°C/W	Junction to Cathode Lead
2θ 1/2	Included Angle Between Half Luminous Intensity Points, Both Axes		65		65			Deg.	I_F = 10 mA See Note 2
η_V	Luminous Efficacy		145			595		Lumen/ Watt	See Note 3

Notes:

1. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
2. Θ1/2 is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
3. Radiant intensity, I_e, in watts steradian, may be found from the equation $I_e = I_V/\eta_V$, where I_V is the luminous intensity in candelas and η_V is the luminous efficacy in lumens/watt.

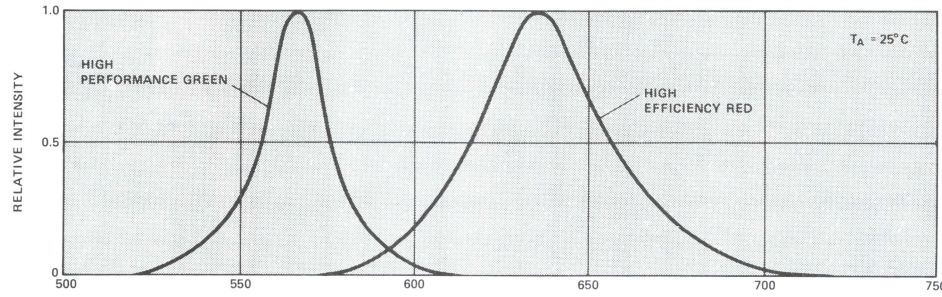


Figure 1. Relative Intensity vs. Wavelength

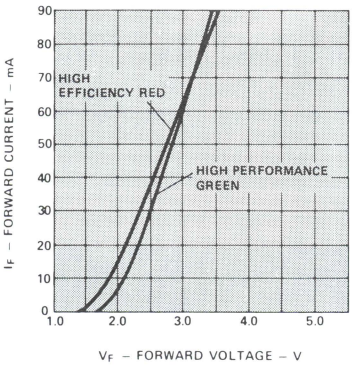


Figure 2. Forward Current vs. Forward Voltage Characteristics.

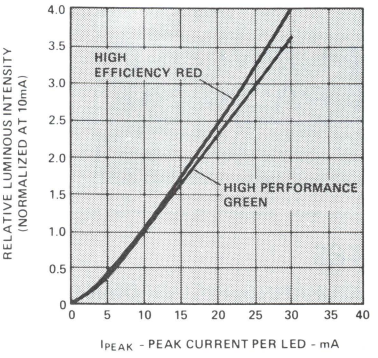


Figure 3. Relative Luminous Intensity vs. DC Forward Current.

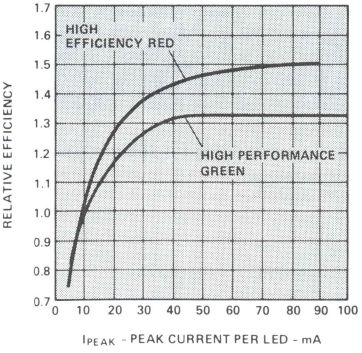


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. LED Peak Current.

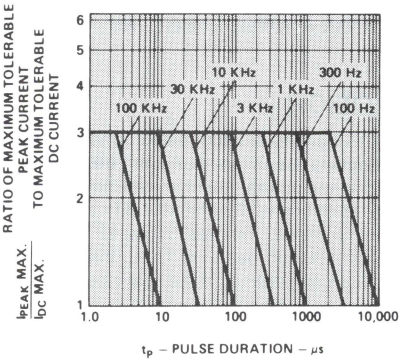


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

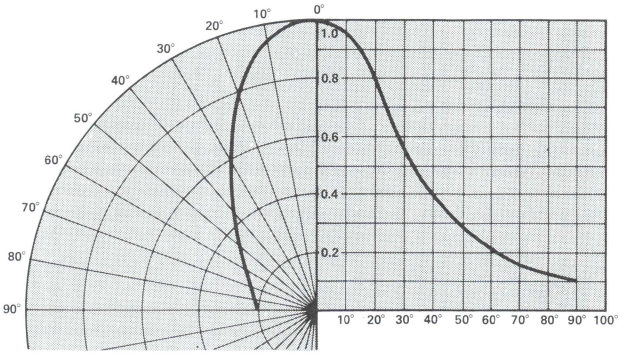


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

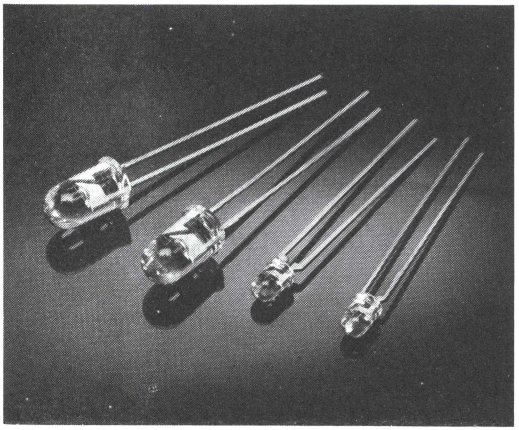
HEWLETT PACKARD

940 nm HIGH RADIANT EMITTERS

T-1¾ (5 mm Diameter) HEMT-3301
T-1 (3 mm Diameter) HEMT-1001

Features

- NONSATURATING, HIGH RADIANT FLUX OUTPUT
- EFFICIENT AT LOW CURRENTS, COMBINED WITH HIGH CURRENT CAPABILITY
- THREE PACKAGE STYLES
- OPERATING TEMPERATURE RANGE -55°C TO +100°C
- MEDIUM-WIDE RADIATION PATTERNS
- RADIATED SPECTRUM MATCHES RESPONSE OF SILICON PHOTODETECTORS



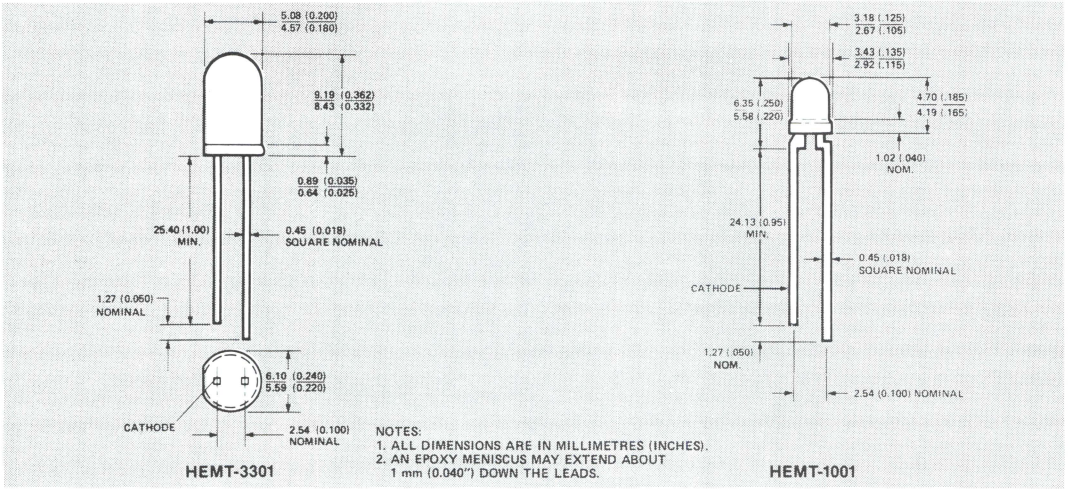
Description

The HEMT-3301 and HEMT-1001 are infrared emitters, using a mesa structure GaAs on GaAs infrared diode, IRED, optimized for maximum quantum efficiency at a peak wavelength of 940 nm. The HEMT-3301 and HEMT-1001 emitters are untinted, undiffused plastic packages with medium-wide radiation patterns. These medium-wide and wide radiation patterns eliminate the beam focusing problems that are encountered with emitters that have narrow radiation patterns. Applications include optical transducers, optical part counters, smoke detectors, covert identification, paper tape and card readers and optical encoders.

Absolute Maximum Ratings at $T_A = 25°C$

Power Dissipation ..... 150 mW
DC Forward Current ..... 100 mA
(Derate as specified in Figure 6)
Peak Forward Current ..... 1000 mA
(Time average current as determined from Figure 7)
IRED Junction Temperature ..... 110°C
Operating and Storage Temperature .... -55°C to +100°C
Lead Soldering Temperature ..... 260°C for 5 seconds
(1.6 mm (0.063 in.) from emitter body)

Package Dimensions



Electrical/Optical Characteristics at T_A = 25°C

Symbol	Description	Min.	Typ.	Max.	Units	Test Conditions	Fig.
I_e	Radiant Intensity HEMT-3301 HEMT-1001	 2.5 1.0	 4.0 2.0		 mW/sr	 I_F = 20 mA	 4,5
$\Delta I_e/\Delta T$	Temperature Coefficient for Radiant Intensity[1]		-0.58		%/°C	Measured at λ_{PEAK}	1
$\Delta\lambda/\Delta T$	Temperature Coefficient for Peak Wavelength[2]		0.3		nm/° C	Measured at λ_{PEAK}	1
λ_{PEAK}	Peak Wavelength		940		nm	Measured at λ_{PEAK}	1
$2\theta_{1/2}$	Half Intensity[3] Total Angle HEMT-3301 HEMT-1001		 50 60		 deg.	 I_F = 20 mA	 8 9
t_r	Output Rise Time (10% to 90%)		1700		ns	I_{PEAK} = 20 mA	
t_f	Output Fall Time (90% to 10%)		700		ns	I_{PEAK} = 20 mA	
C	Capacitance		30		pf	V_F = 0; f = 1 MHz	
V_R	Reverse Breakdown Voltage	5.0			V	I_R = 10 μA	
V_F	Forward Voltage		1.30 1.15	1.50	V	I_F = 100 mA I_F = 20 mA	2
θ_{JC}	Thermal Resistance		120		°C/W	IRED Junction to Cathode Lead	

Notes:
1. Radiant intensity at ambient temperature: $I_e(T_A) = I_e(25°C) + (\Delta I_e/\Delta T)(T_A - 25°C)/100$.
2. Peak wavelength at ambient temperature: $\lambda_{PEAK}(T_A) = \lambda_{PEAK}(25°C) + (\Delta\lambda/\Delta T)(T_A - 25°C)$.
3. $\theta_{1/2}$ is the off-axis angle from emitter centerline where the radiant intensity is half the on-axis value.
4. Approximate radiant flux output within a cone angle of 2θ: $\phi_e(2\theta) = [\phi_e(\theta)/I_e(0)]\ I_e\ (T_A)$; $\phi_e(\theta)/I_e(0)$ obtained from figure 8 or 9.

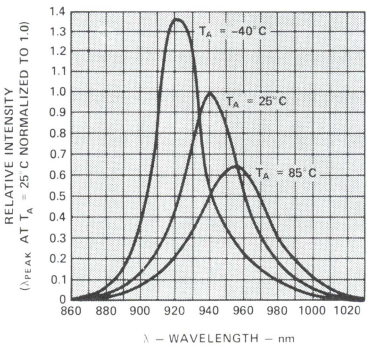


Figure 1. Radiated Spectrum

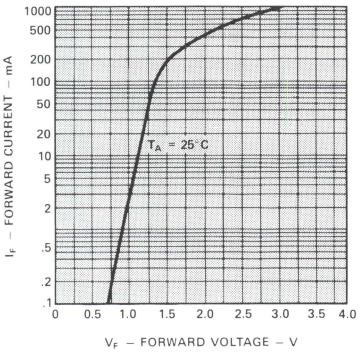


Figure 2. Forward Current vs. Forward Voltage

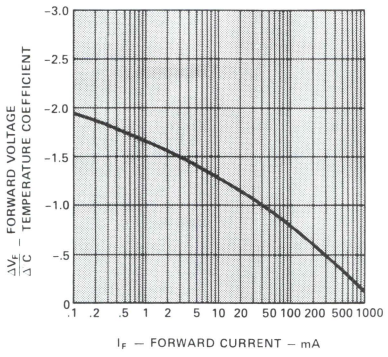


Figure 3. Forward Voltage Temperature Coefficient vs. Forward Current

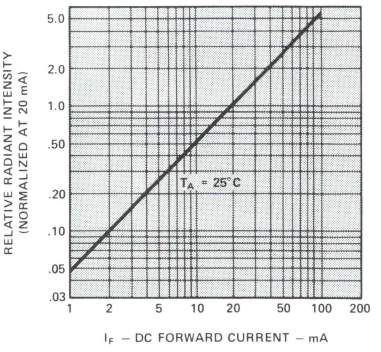


Figure 4. Relative Radiant Intensity vs. DC Forward Current

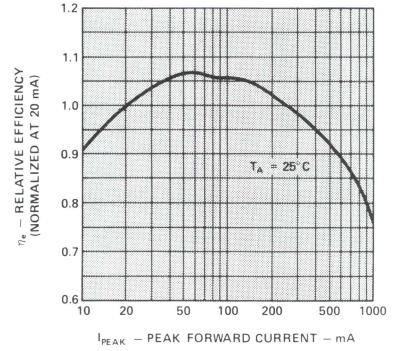


Figure 5. Relative Efficiency vs. Peak Forward Current

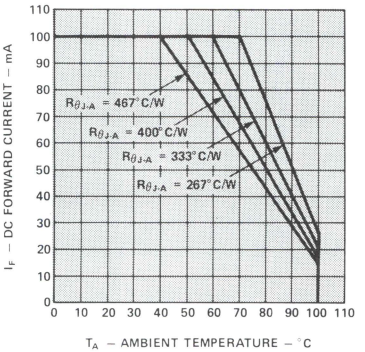


Figure 6. Maximum DC Forward Current vs. Ambient Temperature Derating Based on $T_{J\ MAX}$ = 110°C

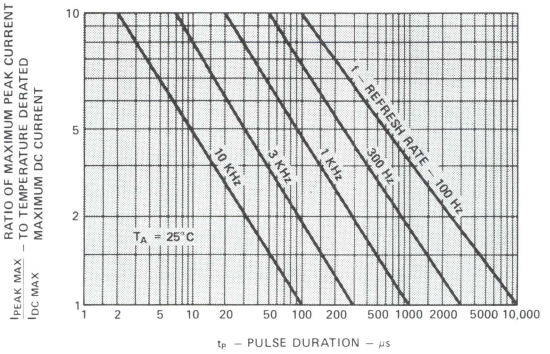


Figure 7. Maximum Tolerable Peak Current vs. Peak Duration ($I_{PEAK\ MAX}$ Determined from Temperature Derated $I_{DC\ MAX}$)

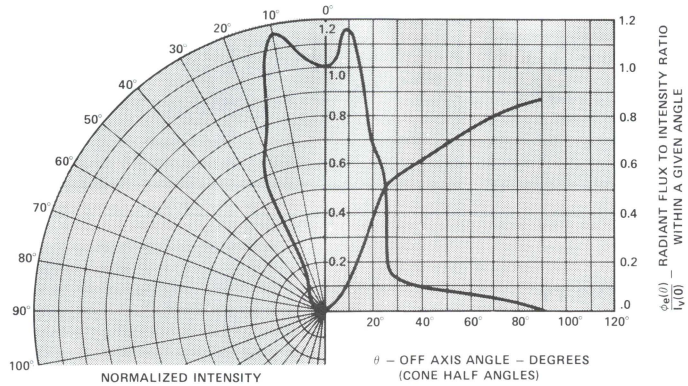


Figure 8. Far Field Radiation Pattern, HEMT-3301

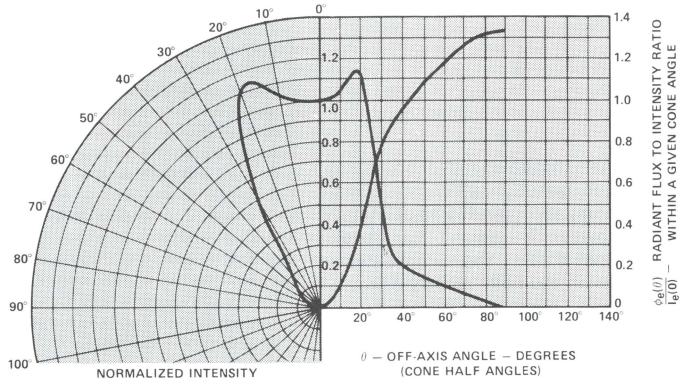


Figure 9. Far Field Radiation Pattern, HEMT-1001

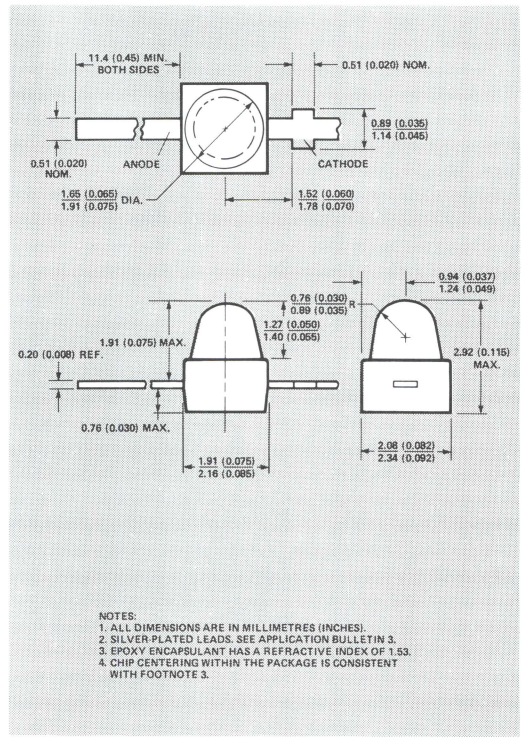
HEWLETT PACKARD

700nm HIGH INTENSITY SUBMINIATURE EMITTER

HEMT-6000

Features

- HIGH RADIANT INTENSITY
- NARROW BEAM ANGLE
- NONSATURATING OUTPUT
- BANDWIDTH: DC TO 5 MHz
- IC COMPATIBLE/LOW CURRENT REQUIREMENT
- VISIBLE FLUX AIDS ALIGNMENT



Description

The HEMT-6000 uses a GaAsP chip designed for optimum tradeoff between speed and quantum efficiency. This optimization allows a flat modulation bandwidth of 5 MHz without peaking, yet provides a radiant flux level comparable to that of 900nm IREDs. The subminiature package allows operation of multiple closely-spaced channels, while the narrow beam angle minimizes crosstalk. The nominal 700nm wavelength can offer spectral performance advantages over 900nm IREDs, and is sufficiently visible to aid optical alignment. Applications include paper-tape readers, punch-card readers, bar code scanners, optical encoders or transducers, interrupt modules, safety interlocks, tape loop stabilizers and fiber optic drivers.

Maximum Ratings at $T_A = 25°C$

Power Dissipation ..... 50 mW
(derate linearly from 70°C @ 1.0mW/°C)

Average Forward Current ..... 20 mA
(derate linearly from 70°C @ 0.4mA/°C)

Peak Forward Current ..... See Figure 5

Operating and Storage Temperature Range ..... -55° to +100°C

Lead Soldering Temperature ..... 260°C for 3 sec. [1.6 mm (0.063 in.) from body]

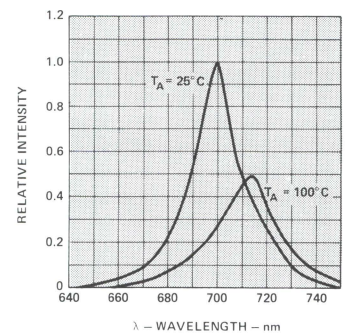


Figure 1. Relative Intensity versus Wavelength.

Electrical/Optical Characteristics at $T_A = 25°C$

Symbol	Description	Min.	Typ.	Max.	Units	Test Conditions	Fig.
I_e	Radiant Intensity along Mechanical Axis	100	250		$\mu W/sr$	I_F = 10 mA	3,4
K_e	Temperature Coefficient of Intensity		-0.005		$°C^{-1}$	Note 1	
η_v	Luminous Efficacy		2.5		lm/W	Note 2	
$2\Theta_{1/2}$	Optical Axis Half Intensity Total Angle		16		deg.	Note 3, I_F = 10 mA	6
λ_{PEAK}	Peak Wavelength (Range)		690-715		nm	Measured @ Peak	1
$\Delta\lambda_{PEAK}/\Delta T$	Spectral Shift Temperature Coefficient		.193		nm/°C	Measured @ Peak, Note 4	
t_r	Output Rise Time (10%-90%)		70		ns	I_{PEAK} = 10 mA	
t_f	Output Fall Time (90%-10%)		40		ns	I_{PEAK} = 10 mA	
C_o	Capacitance		65		pF	V_F = 0; f = 1 MHz	
BV_R	Reverse Breakdown Voltage	5	12		V	I_R = 100 μA	
V_F	Forward Voltage		1.5	1.8	V	I_F = 10 mA	2
$\Delta V_F/\Delta T$	Temperature Coefficient of V_F		-2.1		mV/°C	I_F = 100 μA	
Θ_{JC}	Thermal Resistance		140		°C/W	Junction to cathode lead	

NOTES:
1. $I_e(T) = I_e\,(25°C)\exp[K_e\,(T - 25°C)]$.
2. $I_v = \eta_v I_e$ where I_v is in candela, I_e in watts/steradian, and η_v in lumen/watt.
3. $\Theta_{1/2}$ is the off-axis angle at which the radiant intensity is half the intensity along the optical axis. The deviation between the mechanical and the optical axis is typically within a conical half-angle of three degrees.
4. $\lambda_{PEAK}\,(T) = \lambda_{PEAK}\,(25°C) + (\Delta\lambda_{PEAK}/\Delta T)\,(T - 25°C)$

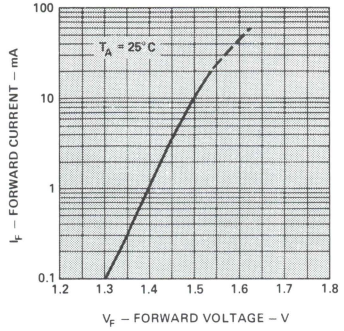


Figure 2. Forward Current versus Forward Voltage.

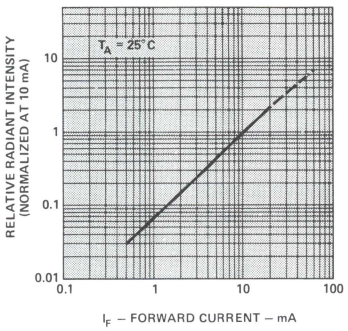


Figure 3. Relative Radiant Intensity versus Forward Current.

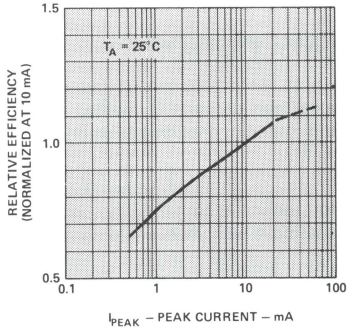


Figure 4. Relative Efficiency (Radiant Intensity per Unit Current) versus Peak Current.

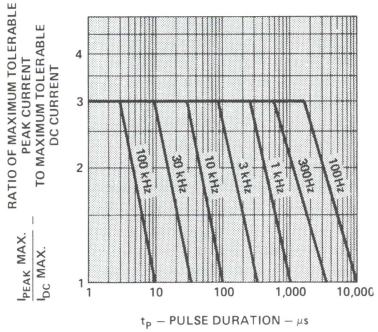


Figure 5. Maximum Tolerable Peak Current versus Pulse Duration. (I_{DC} MAX as per MAX Ratings)

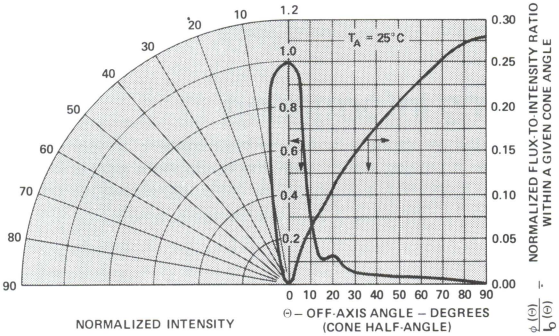


Figure 6. Far-Field Radiation Pattern.

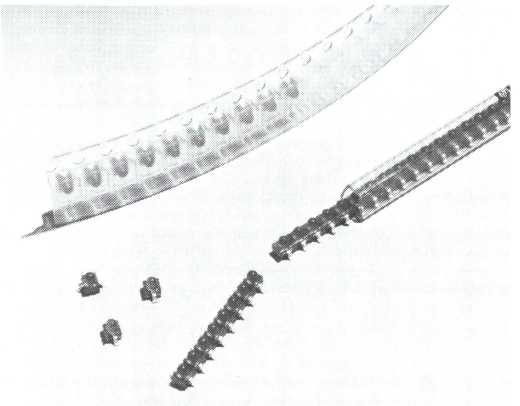
HEWLETT PACKARD

SURFACE MOUNT OPTION FOR SUBMINIATURE LAMPS GULL WING LEAD CONFIGURATION

INDIVIDUAL SUBMINIATURE LAMP SUPPLIED IN 12mm TAPE — OPTION 011
SUBMINIATURE ARRAY SUPPLIED IN A SHIPPING TUBE — OPTION 013

Features

- GULL WING LEAD CONFIGURATION, INDIVIDUAL SUBMINIATURE LAMPS AND ARRAYS
- COMPATIBLE WITH AUTOMATIC PLACEMENT EQUIPMENT
- COMPATIBLE WITH VAPOR PHASE REFLOW SOLDER PROCESSES
- LOW PACKAGE PROFILE
- WIDE VIEWING ANGLE
- LONG LIFE — SOLID STATE RELIABILITY
- INDIVIDUAL SUBMINIATURE LAMPS ARE SUPPLIED IN 12mm TAPE
- SUBMINIATURE ARRAYS ARE SUPPLIED IN TUBES



Description

These subminiature solid state lamps are encapsulated in an axial lead package of molded epoxy. They utilize a tinted, diffused lens providing high on-off contrast and wide angle viewing.

The leads of this device are bent in a gull wing configuration for surface mounting. The device can be mounted using automatic placement equipment.

The individual gull wing subminiature lamp is supplied in 12mm tape on seven inch reels per ANSI/EIA standard RS-481 specifications. Gull wing subminiature arrays are supplied in shipping tubes. The lamp can be mounted with either batch or in line vapor phase reflow solder processes.

Subminiature lamps for surface mount applications are available in standard red, high efficiency red, yellow, green, integrated resistor, and low current versions.

Ordering Information

To obtain gull wing surface mount subminiature lamps, order the basic catalog device with the appropriate option code. Note: Option 011 is available for individual subminiature lamps only. Option 013 is available for subminiature arrays only.

Device Selection Guide

Option	Description
Option 011	Individual subminiature lamps in gull wing configuration. Supplied in 12mm tape on seven inch reels; 1500 pieces per reel. Minimum order quantity and order increment are 1500 pieces.
Option 012	Bulk
Option 013 (Arrays only)	Subminiature array in gull wing configuration. Supplied in shipping tubes.

Examples:

HLMP-6300	HLMP-6658
Option 011	Option 013
High Efficiency Red	High Efficiency Red, 8 Element Array
Supplied on Tape	Supplied in Tubes

Vapor Phase Reflow Solder Rating

Absolute Maximum Rating

Vapor Phase Soldering Temperature	215° C for 3 minutes Material FC-5311

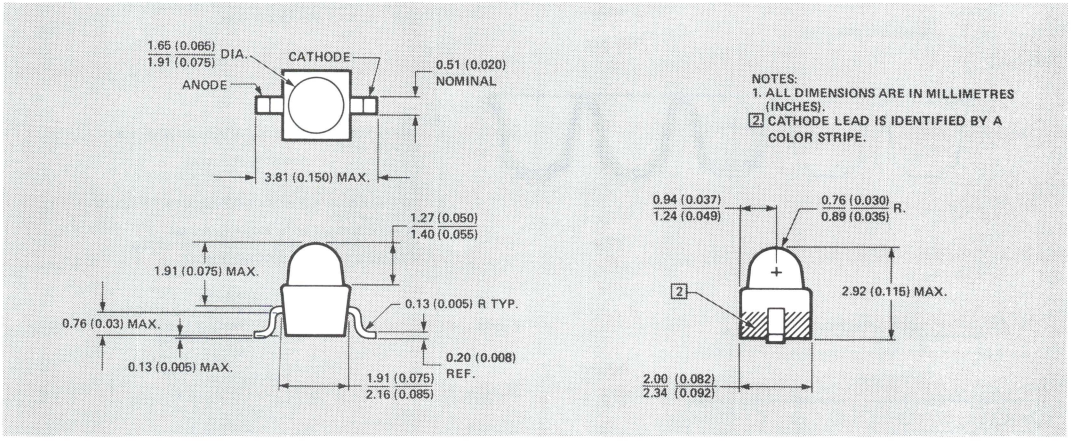
Note: Lead soldering maximum rating is 260° C for 3 seconds.

Absolute Maximum Ratings and Electrical/Optical Characteristics

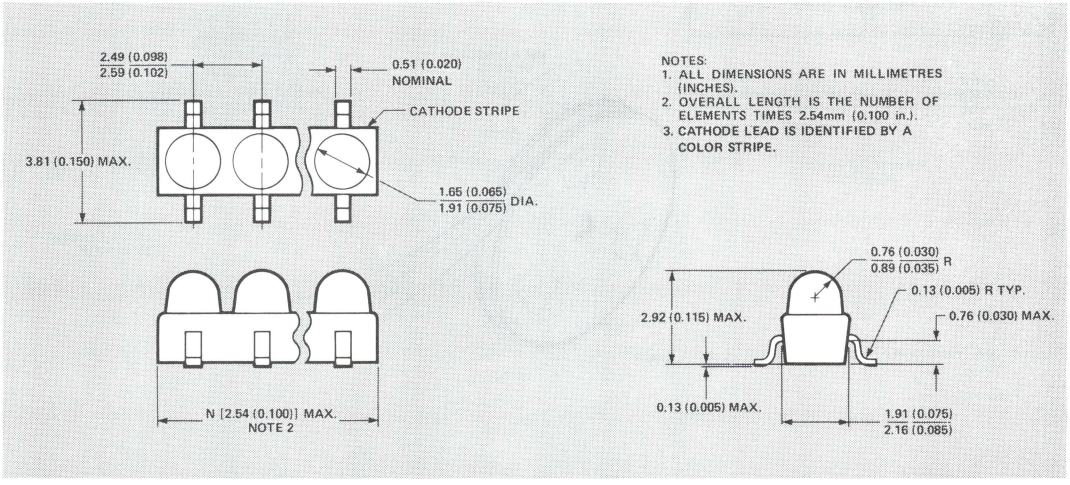
The absolute maximum ratings and electrical/optical specifications are identical to the basic catalog device, except for the vapor phase soldering rating as specified at left.

Package Dimensions

INDIVIDUAL SUBMINIATURE

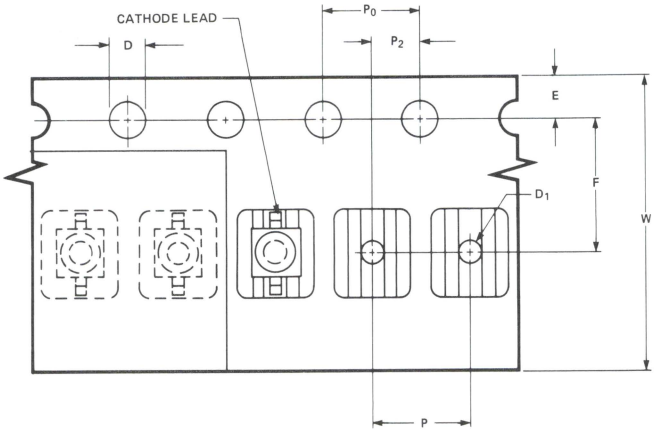


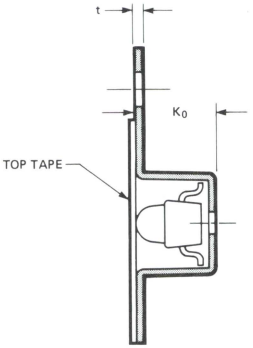
SUBMINIATURE ARRAY



SOLID STATE LAMPS

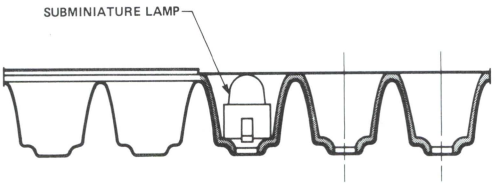
12 mm TAPE AND REEL



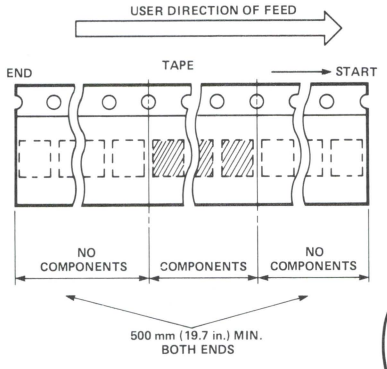


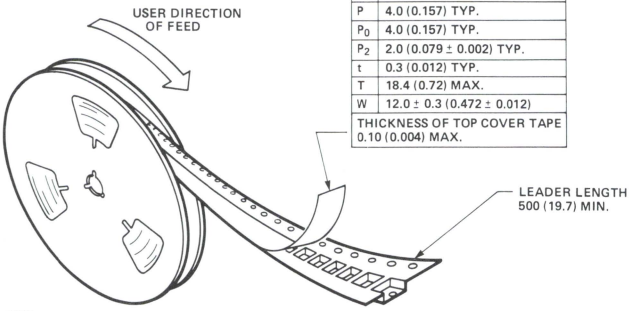
FEED DIRECTION

TOLERANCES (UNLESS OTHERWISE SPECIFIED):
.X ± .1; .XX ± .05 (.XXX ± .004)



NOTES:
1. EMPTY COMPONENT POCKETS SEALED WITH TOP COVER TAPE.
2. 7 INCH REEL - 1,500 PIECES PER REEL.
3. MINIMUM LEADER LENGTH AT EITHER END OF THE TAPE IS 500mm.
4. THE MAXIMUM NUMBER OF CONSECUTIVE MISSING LAMPS IS TWO.
5. IN ACCORDANCE WITH ANSI/EIA RS-481 SPECIFICATIONS, THE CATHODE IS ORIENTED TOWARDS THE TAPE SPROCKET HOLE.

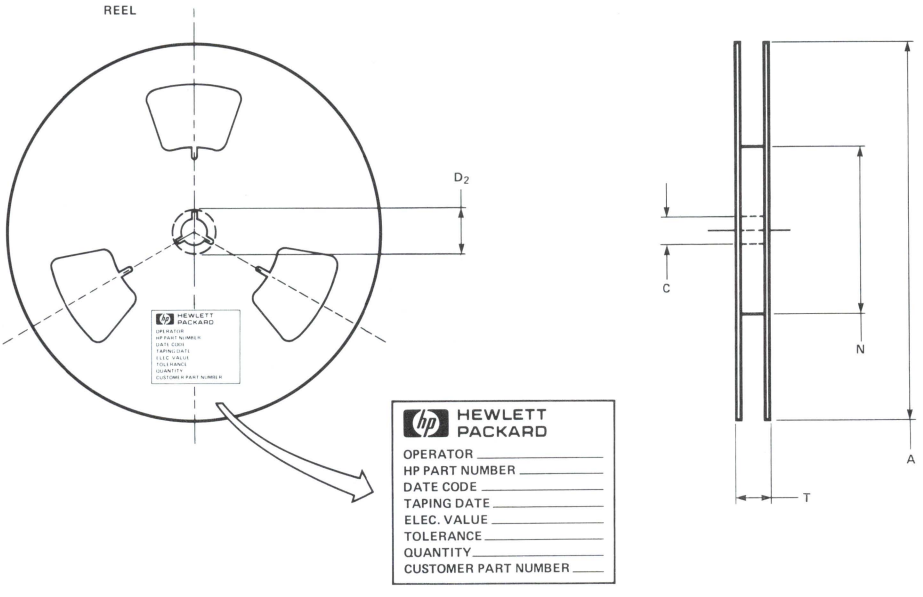




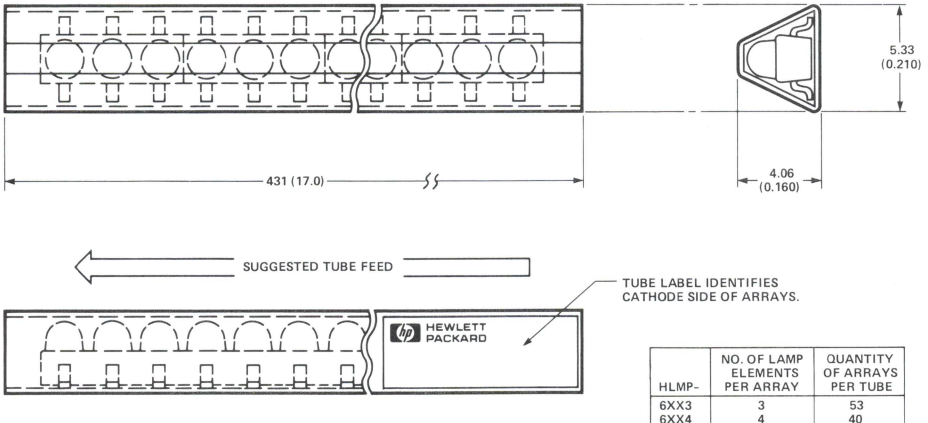
DIMENSIONS PER ANSI/EIA STANDARD RS-481* ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).	
A	178.0 ± 2.0 (7.0 ± 0.08) DIA.
C	13.0 (0.512) DIA. TYP.
D	$1.5^{+0.1}_{-0.0}$ ($0.059^{+0.004}_{-0.000}$) DIA.
D_1	1.0 (0.039) DIA. MIN.
D_2	20.2 (0.795) DIA. MIN.
E	1.75 ± 0.1 (0.069)
F	5.50 (0.127 ± 0.002)
K_0	3.05 (0.120) TYP.
N	50.0 (1.970) MIN.
P	4.0 (0.157) TYP.
P_0	4.0 (0.157) TYP.
P_2	2.0 (0.079 ± 0.002) TYP.
t	0.3 (0.012) TYP.
T	18.4 (0.72) MAX.
W	12.0 ± 0.3 (0.472 ± 0.012)
THICKNESS OF TOP COVER TAPE 0.10 (0.004) MAX.	

*EXCEPTION: THE EJECTOR-PIN HOLE (D_1) IS 1.0 (0.039) DIA. MIN.

REEL



ARRAY SHIPPING TUBE



HLMP-	NO. OF LAMP ELEMENTS PER ARRAY	QUANTITY OF ARRAYS PER TUBE
6XX3	3	53
6XX4	4	40
6XX5	5	32
6XX6	6	26
6XX8	8	20

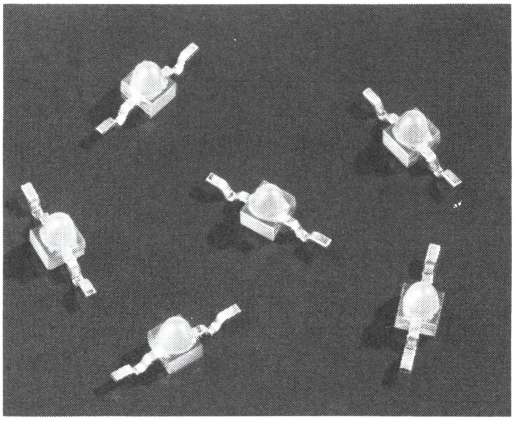
HEWLETT PACKARD

SURFACE MOUNT OPTION FOR SUBMINIATURE LAMPS — "YOKE" LEAD CONFIGURATION

INDIVIDUAL SUBMINIATURE LAMP SUPPLIED IN 12 mm TAPE —OPTION 021
INDIVIDUAL SUBMINIATURE LAMP SUPPLIED IN BULK —OPTION 022

Features

- **"YOKE" LEAD CONFIGURATION FOR THROUGH HOLE MOUNTING ON PC BOARD**
- **COMPATIBLE WITH AUTOMATIC PLACEMENT EQUIPMENT**
- **COMPATIBLE WITH VAPOR PHASE REFLOW SOLDER PROCESSES**
- **LOW PACKAGE PROFILE**
- **WIDE VIEWING ANGLE**
- **LONG LIFE—SOLID STATE RELIABILITY**
- **SUPPLIED IN 12 mm TAPE OR BULK**



Description

These subminiature solid state lamps are encapsulated in an axial lead package of molded epoxy. The lens is diffused for even light dispersion.

The lamps are designed to be inserted through holes in the PC board to backlight switches, membrane panels, or appliques. Other backlighting applications are equally suitable. As shown in Figure 1, the leads are specially formed to give two features: mechanical strain relief and adequate solder pads.

Automatic placement equipment may be used to mount the LEDs on the PC board if the designer selects the 021 option. These lamps are supplied in 12 mm tape on seven inch reels per ANSI/EIA standard RS-481 specifications. Bulk lamps are available under the 022 option code. The lamps can be mounted using either batch or in line vapor phase reflow solder processes.

Subminiature lamps for surface mount applications are available in standard red, high efficiency red, yellow, green, integrated resistor, and low current versions.

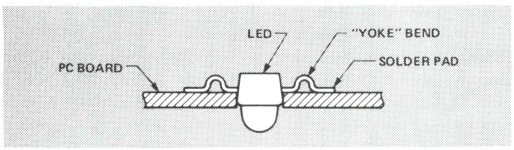


Figure 1.

Ordering Information

To obtain surface mount subminiature lamps with the "yoke" lead configuration, order the basic catalog device with the appropriate option code.

Device Selection Guide

Option	Description
Option 021	Individual subminiature lamps in "yoke" lead configuration. Supplied in 12 mm tape on seven inch reels; 1500 pieces per reel. Minimum order quantity and order increment is 1500 pieces.
Option 022	Individual subminiature lamps in "yoke" lead configuration. Supplied in bulk.

Examples:

HLMP-6300	HLMP-6400
Option 021	Option 022
High Efficiency Red	Yellow
Supplied on Tape	Supplied in Bulk

Vapor Phase Reflow Solder Rating

Absolute Maximum Rating

Vapor Phase Soldering Temperature	215°C for 3 minutes Material FC-5311

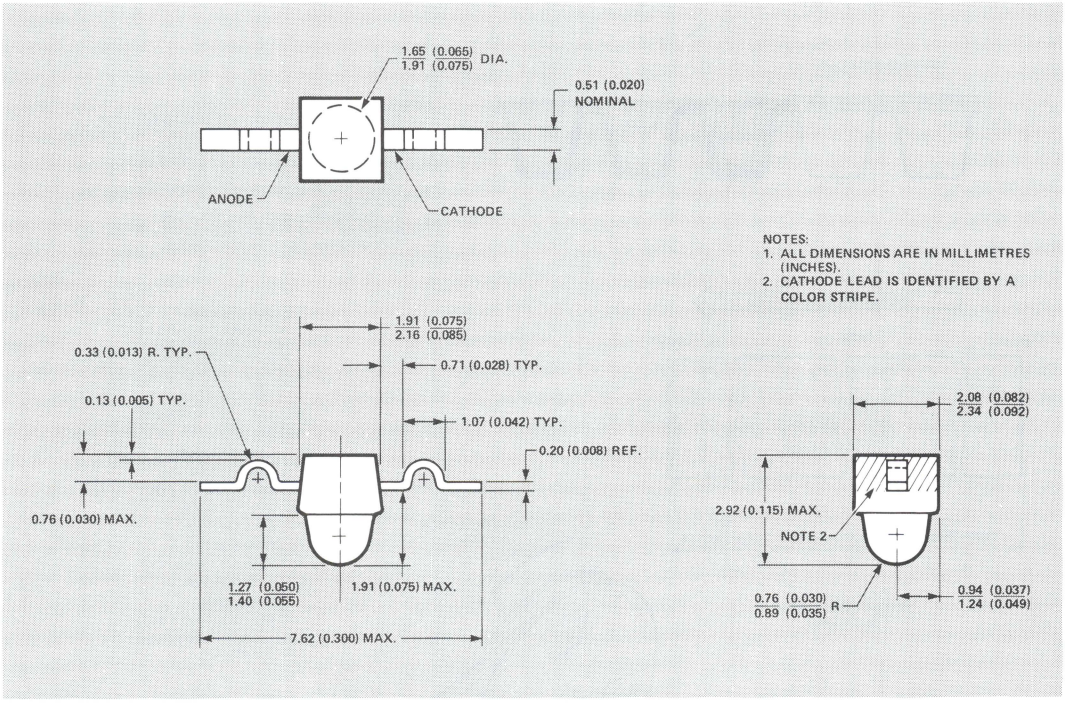
NOTE: Lead soldering maximum rating is 260°C for 3 seconds.

Absolute Maximum Ratings and Electrical/Optical Characteristics

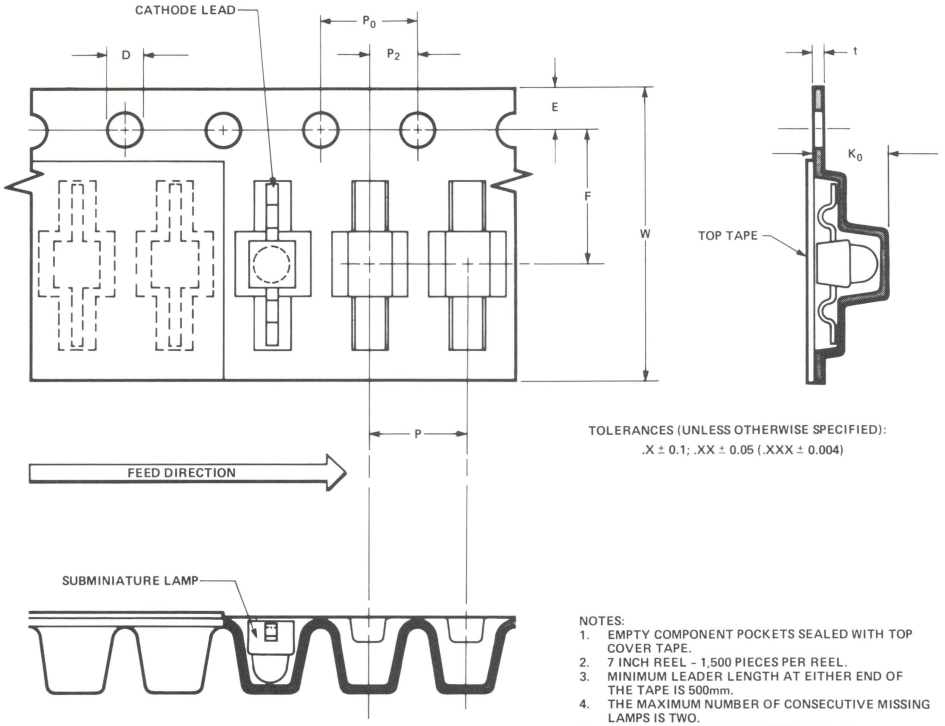
The absolute maximum ratings and electrical/optical specifications are identical to the basic catalog device, except for the vapor phase soldering rating as specified at left.

Package Dimensions

INDIVIDUAL SUBMINIATURE LAMP

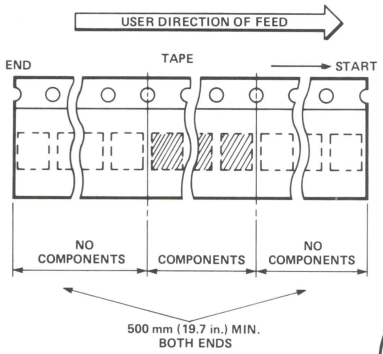


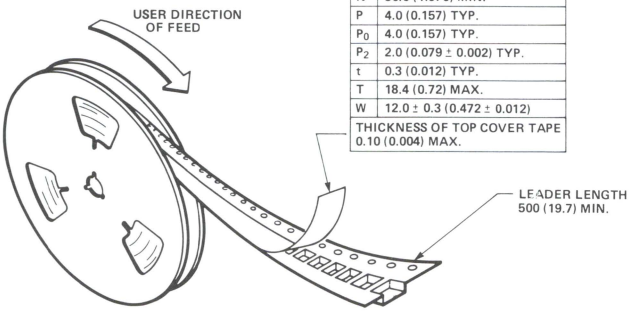
12mm TAPE AND REEL



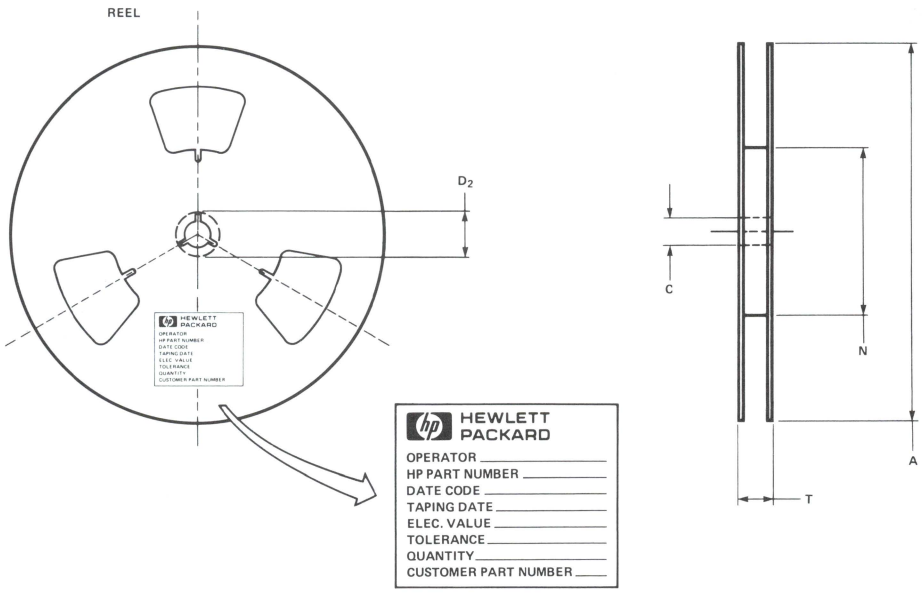
TOLERANCES (UNLESS OTHERWISE SPECIFIED):
.X ± 0.1; .XX ± 0.05 (.XXX ± 0.004)

NOTES:
1. EMPTY COMPONENT POCKETS SEALED WITH TOP COVER TAPE.
2. 7 INCH REEL - 1,500 PIECES PER REEL.
3. MINIMUM LEADER LENGTH AT EITHER END OF THE TAPE IS 500mm.
4. THE MAXIMUM NUMBER OF CONSECUTIVE MISSING LAMPS IS TWO.
5. IN ACCORDANCE WITH ANSI/EIA RS-481 SPECIFICATIONS, THE CATHODE IS ORIENTED TOWARDS THE TAPE SPROCKET HOLE.





DIMENSIONS PER ANSI/EIA STANDARD RS-481 ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).	
A	178.0 ± 2.0 (7.0 ± 0.08) DIA.
C	13.0 (0.512) DIA. TYP.
D	1.55 (0.061 ±0.002) DIA.
D_2	20.2 (0.795) DIA. MIN.
E	1.75 ± 0.1 (0.069)
F	5.50 (0.127 ± 0.002)
K_0	3.05 ± 0.1(0.120) TYP.
N	50.0 (1.970) MIN.
P	4.0 (0.157) TYP.
P_0	4.0 (0.157) TYP.
P_2	2.0 (0.079 ± 0.002) TYP.
t	0.3 (0.012) TYP.
T	18.4 (0.72) MAX.
W	12.0 ± 0.3 (0.472 ± 0.012)
THICKNESS OF TOP COVER TAPE 0.10 (0.004) MAX.	


REEL
D_2
HEWLETT PACKARD
OPERATOR
HP PART NUMBER
DATE CODE
TAPING DATE
ELEC. VALUE
TOLERANCE
QUANTITY
CUSTOMER PART NUMBER
HEWLETT PACKARD
OPERATOR
HP PART NUMBER
DATE CODE
TAPING DATE
ELEC. VALUE
TOLERANCE
QUANTITY
CUSTOMER PART NUMBER
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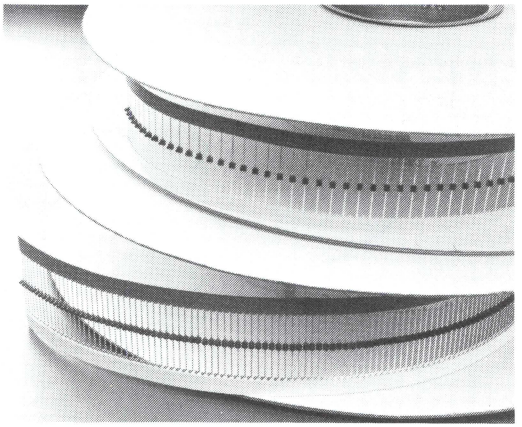
HEWLETT PACKARD

TAPE AND REEL SUBMINIATURE LAMPS

Tape and Reel Spacing: 2.54mm (0.100 inch) — OPTION P01
5.00mm (0.200 inch) — OPTION P02

Features

- **COMPATIBLE WITH AXIAL LEAD AUTOMATIC INSERTION EQUIPMENT**
- **REEL PACKAGING SIMPLIFIES HANDLING AND TESTING**



Description

Subminiature lamps are available on tape and reel. The Option lamp devices have axial leads with 2.54 mm (0.100 inch) spacing for automatic insertion into PC Boards by radial lead insertion equipment. The Option P02 lamp devices have axial leads with 5.00 mm (0.200 inch) spacing packaged on tape and reel for ease of handling.

Ordering Information

To order Subminiature lamps packaged on tape and reel, include the appropriate option code along with the device catalog part number. Example; to order the HLMP-6300 on tape and reel, order as follows: HLMP-6300 — P01. Minimum order quantities vary by part number. Orders must be placed in reel increments. Please contact your local Hewlett-Packard sales office or franchised Hewlett-Packard distributor for a complete list of lamps available on tape and reel.

Absolute Maximum Ratings and Electrical/Optical Characteristics

The absolute maximum ratings, mechanical dimension tolerances and electrical optical characteristics for lamps packaged on tape and reel are identical to the basic catalog device. Refer to the basic data sheet for the specified values.

Device Selection Guide

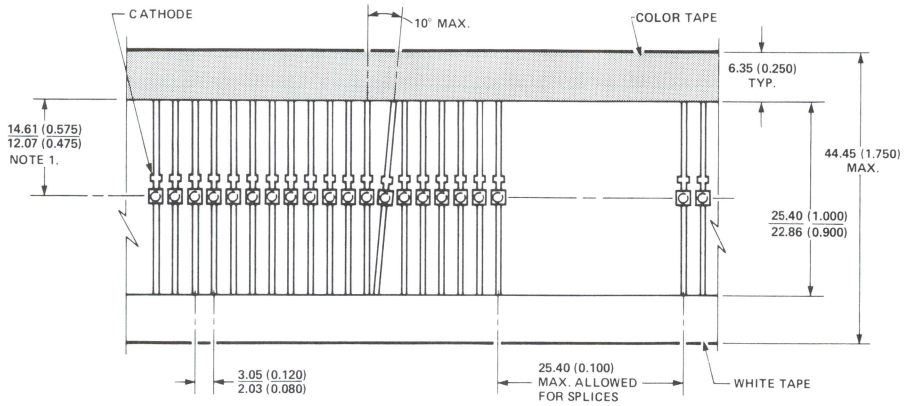
Option	Description
P01	Tape and reel, 2.54 mm (0.100 inch) spaced axial leads.
P02	Tape and reel, 5.00 mm (0.200 inch) spaced axial leads.

Option	Quantity/Reel	Order Increments
P01	5,000 or 1,000	1,000
P02	2,500 or 1,000	1,000

Notes:
1. Minimum leader length at either end of tape is 2 blank part spaces.
2. Silver saver paper is used as the interlayer for silver plated lead devices.
3. The maximum number of consecutive missing lamps is 2. Drawings and option codes apply to devices with cathode tab intact only.

OUTLINE A (TAPE AND REEL) — OPTION P01

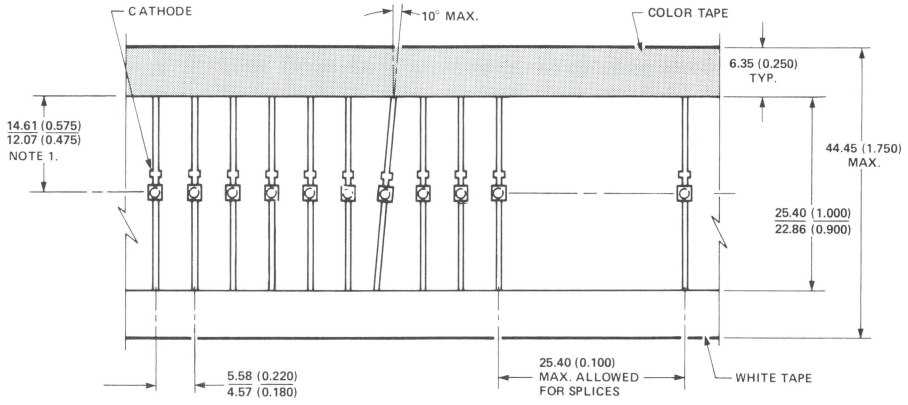
2.54 mm (0.100 inch) spacing



NOTE: LED'S MUST FALL WITHIN 0.020" OF A COMMON CENTER.

OUTLINE B (TAPE AND REEL) — OPTION P02

5.08 mm (0.200 inch) spacing



NOTE: LED'S MUST FALL WITHIN 0.020" OF A COMMON CENTER.

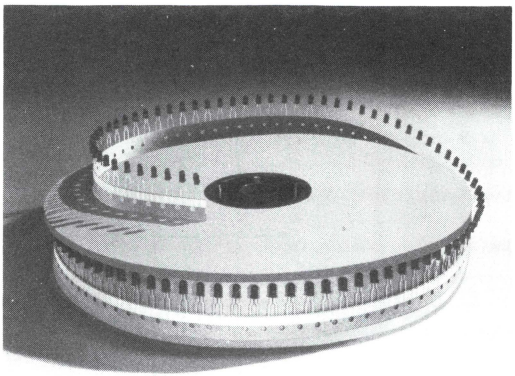
HEWLETT PACKARD

TAPE AND REEL SOLID STATE LAMPS

Leads: 5mm (0.197 inch) Formed Leads — OPTION 001
2.54mm (0.100 inch) Straight Leads — OPTION 002

Features

- **COMPATIBLE WITH RADIAL LEAD AUTOMATIC INSERTION EQUIPMENT**
- **MEETS DIMENSIONAL SPECIFICATIONS OF IEC PUBLICATION 286 AND ANSI/EIA STANDARD RS-468 FOR TAPE AND REEL**
- **REEL PACKAGING SIMPLIFIES HANDLING AND TESTING**
- **T-1 AND T-1 3/4 LED LAMPS AVAILABLE PACKAGED ON TAPE AND REEL**
- **5 mm (0.197 INCH) FORMED LEAD AND 2.54 mm (0.100 INCH) STRAIGHT LEAD SPACING AVAILABLE**



Description

T-1 and T-1 3/4 LED lamps are available on tape and reel as specified by the IEC Publication 286 and ANSI/EIA Standard RS-468. The Option 001 lamp devices have formed leads with 5 mm (0.197 inch) spacing for automatic insertion into PC boards by radial lead insertion equipment. The Option 002 lamp devices have straight leads with 2.54 mm (0.100 inch) spacing, packaged on tape and reel for ease of handling. T-1 lamps are packaged 1800/reel. T-1 3/4 lamps are packaged 1300/reel.

Device Selection Guide

Option	Description
001	Tape and reel, 5 mm (0.197 inch) formed leads.
002	Tape and reel, 2.54 mm (0.100 inch) straight leads.

Package	Quantity/Reel	Order Increments
T-1	1800	1800
T-1 3/4	1300	1300

Ordering Information

To order LED lamps packaged on tape and reel, include the appropriate option code along with the device catalog part number. Example: to order the HLMP-3300 on tape and reel with formed leads (5 mm lead spacing) order as follows: HLMP-3300 Option 001. Minimum order quantities vary by part number. Orders must be placed in reel increments. Please contact your local Hewlett-Packard sales office or franchised Hewlett-Packard distributor for a complete list of lamps available on tape and reel.

LED lamps with 0.46 mm (0.018 inch) square leads with 5 mm (0.197 inch) lead spacing are recommended for use with automatic insertion equipment. It is suggested that insertion machine compatibility be confirmed.

Absolute Maximum Ratings and Electrical/Optical Characteristics

The absolute maximum ratings, mechanical dimension tolerances and electrical/optical characteristics for lamps packaged on tape and reel are identical to the basic catalog device. Refer to the basic data sheet for the specified values.

Notes:

1. Minimum leader length at either end of tape is 3 blank part spaces.
2. Silver saver paper is used as the interlayer for silver plated lead devices.
3. The maximum number of consecutive missing lamps is 3.
4. In accordance with EIA and IEC specs, the anode lead leaves the reel first.
5. Drawings apply to devices with 0.46 mm (0.018 inch) square leads only. Contact Hewlett-Packard Sales Office for dimensions of 0.635 mm (0.025 inch) square lead devices.

Tape and Reel LED Configurations

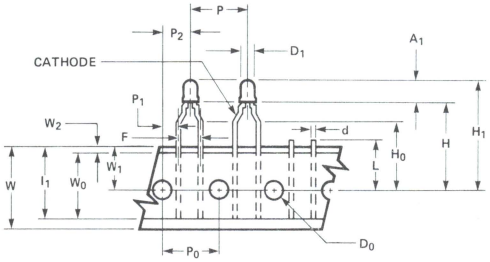


Figure 1. T-1 High Profile Lamps, Option 001

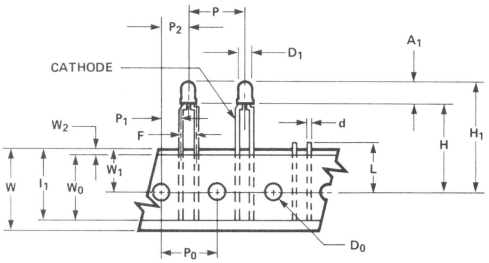


Figure 2. T-1 High Profile Lamps, Option 002

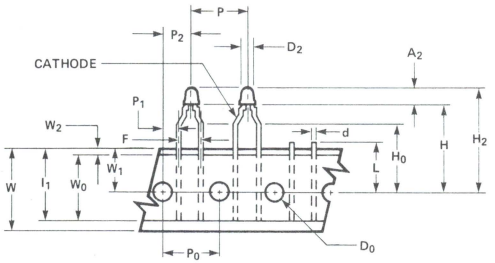


Figure 3. T-1 Low Profile Lamps, Option 001

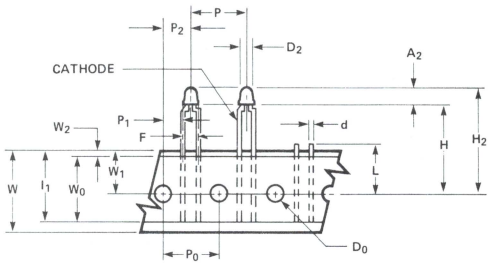


Figure 4. T-1 Low Profile Lamps, Option 002

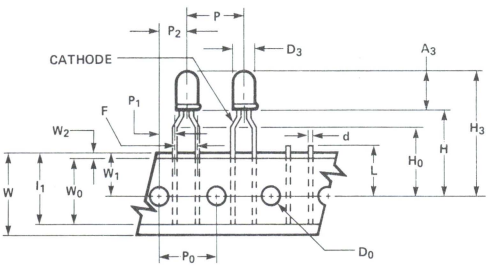


Figure 5. T-1 3/4 High Profile Lamps, Option 001

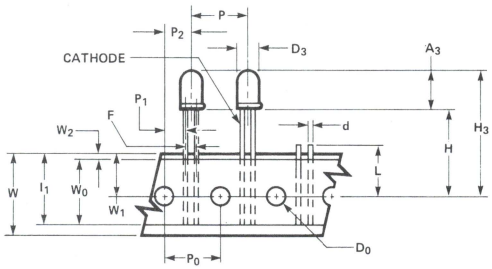


Figure 6. T-1 3/4 High Profile Lamps, Option 002

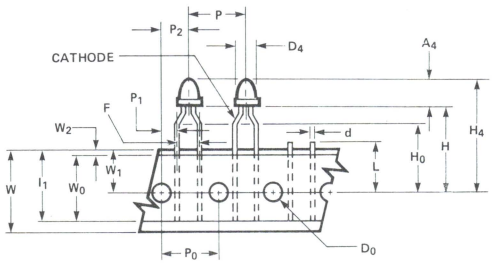


Figure 7. T-1 3/4 Low Profile Lamps, Option 001

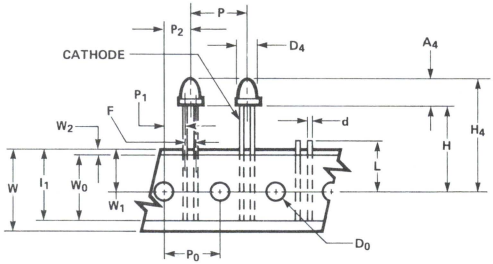
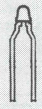
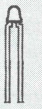
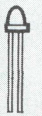


Figure 8. T-1 3/4 Low Profile Lamps, Option 002

SOLID STATE LAMPS

Dimensional Specifications for Tape and Reel

Item	Option 001	002	Symbol	Specification	Notes
T1 High Profile Body Height			A1	4.70 (0.185) / 4.19 (0.165)	
Body Diameter			D1	3.18 (0.125) / 2.67 (0.105)	
Component Height			H1	25.7 (1.012) Max.	
T1 Low Profile Body Height			A2	3.73 (0.147) / 3.23 (0.127)	
Body Diameter			D2	3.05 (0.120) / 2.79 (0.110)	
Component Height			H2	24.7 (0.974) Max.	
T1-3/4 High Profile Body Height			A3	9.19 (0.362) / 8.43 (0.332)	
Body Diameter			D3	5.08 (0.200) / 4.32 (0.170)	
Component Height			H3	30.2 (1.189) Max.	
T1-3/4 Low Profile Body Height			A4	6.35 (0.250) / 5.33 (0.210)	
Body Diameter			D4	5.08 (0.200) / 4.32 (0.170)	
Component Height			H4	27.4 (1.079) Max.	
Lead wire thickness			d	0.45 (0.018)	Square Leads
Pitch of component			P	13.7 (0.539) / 11.7 (0.461)	
Feed hole pitch			P_O	12.9 (0.508) / 12.5 (0.492)	Cumulative error: 1.0 mm/20 pitches.
Feed hole center to lead center			P1	4.55 (0.179) / 3.15 (0.124)	Measure at crimp bottom. 5.78/3.68 (0.227/0.1448) for straight leads
Hole center to component center			P2	7.35 (0.289) / 5.35 (0.211)	
Lead to lead distance			F	5.40 (0.213) / 4.90 (0.193)	2.54 (0.100) nominal for straight leads.
Component alignment, front-rear			Δh	0 ± 1.0 (0.039)	Figure 9
Tape width			W	18.5 (0.728) / 17.5 (0.689)	
Hold down tape width			W_O	15.3 (0.602) / 14.7 (0.579)	
Hole position			W1	9.75 (0.384) / 8.50 (0.335)	
Hold down tape position			W2	0.5 (0.020) Max.	
Height of component from hole center			H	21.0 (0.827) / 20.0 (0.787)	
Lead clinch height			H_O	16.5 (0.650) / 15.5 (0.610)	
Feed hole diameter			D_O	4.20 (0.165) / 3.80 (0.150)	
Total tape thickness			t	0.90 (0.035) / 0.50 (0.020)	Paper thickness: 0.55 (0.022) / 0.45 (0.018) Figure 9
Length of snipped lead			L	11.0 (0.433) Max.	
Lead length under hold down tape			l1	14.5 (0.571) Min.	

Note:

1. Dimensions in millimetres (inches), maximum/minimum.

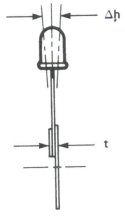


Figure 9. Front to Rear Alignment and Tape Thickness, Typical All Device Types

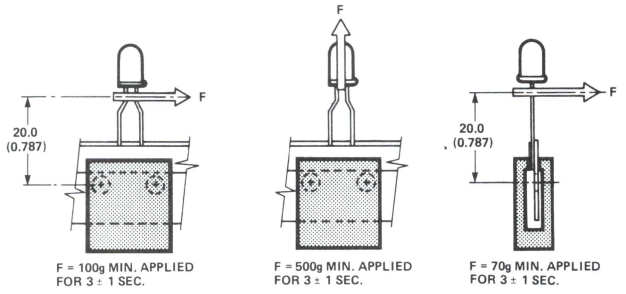


Figure 10. Device Retention Tests and Specifications

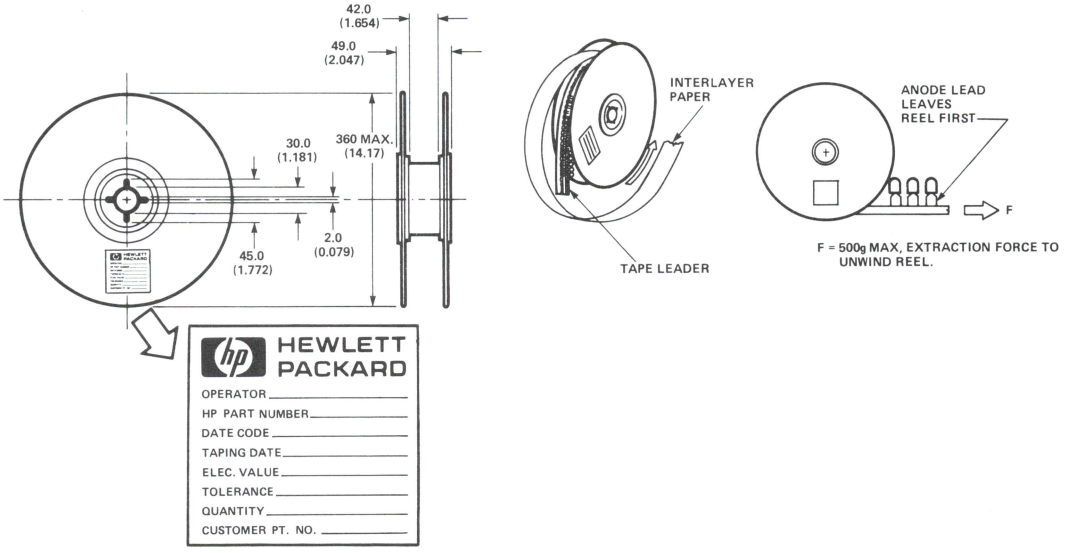


Figure 11. Reel Configuration and Labeling

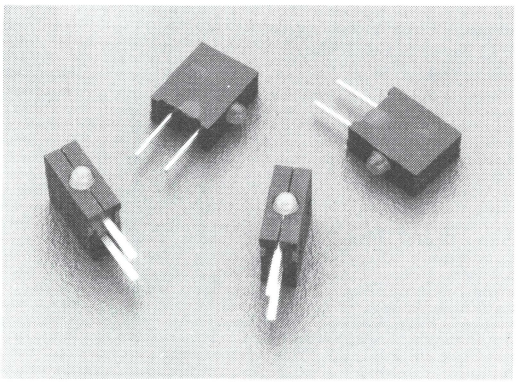
HEWLETT PACKARD

SUBMINIATURE LED RIGHT ANGLE INDICATORS

RED HLMP-6000-010
HIGH EFFICIENCY RED HLMP-6300-010
YELLOW HLMP-6400-010
GREEN HLMP-6500-010

Features

- **IDEAL FOR PC BOARD STATUS INDICATION**
- **SIDE STACKABLE ON 2.54 mm (0.100 in) CENTERS**
- **AVAILABLE IN FOUR COLORS**
- **HOUSING MEETS UL 94V-O FLAMMABILITY SPECIFICATIONS**
- **ADDITIONAL CATALOG LAMPS AVAILABLE AS OPTIONS**



Description

The Hewlett-Packard series of Subminiature Right Angle Indicators are industry standard status indicators that incorporate tinted diffused LED lamps in black plastic housings. The 2.54 mm (0.100 in) wide packages may be side stacked for maximum board space savings. The silver plated leads are in line on 2.54 mm (0.100 in) centers, a standard spacing that makes the PC board layout straightforward. These products are designed to be used as back panel diagnostic indicators and logic status indicators on PC boards.

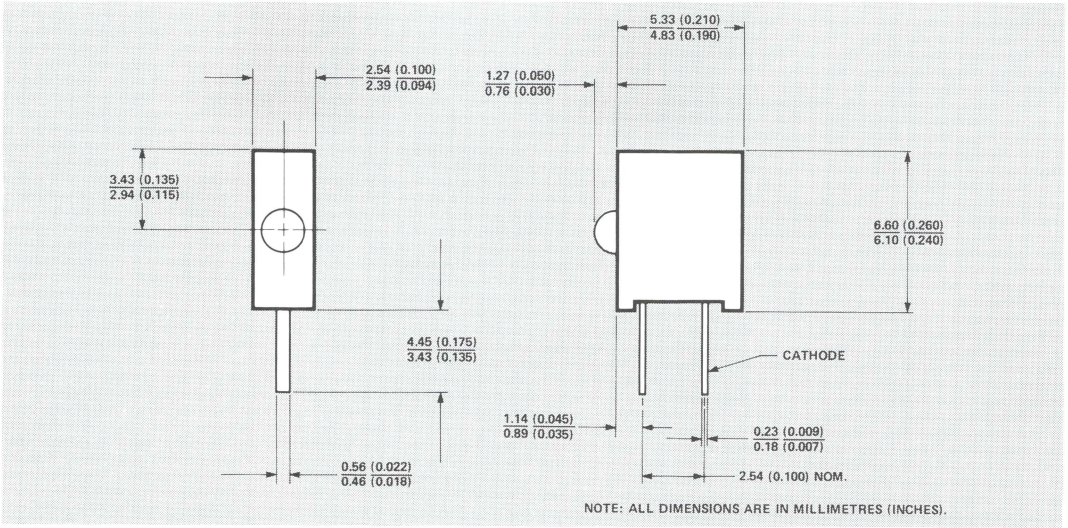
Ordering Information

To order Subminiature Right Angle indicators, order the base part number and add the option code 010. For price and delivery on Resistor Subminiature Right Angle Indicators and other subminiature LEDs not indicated above, please contact your nearest H.P. Components representative.

Absolute Maximum Ratings and Other Electrical/Optical Characteristics

The absolute maximum ratings and typical device characteristics are identical to those of the Subminiature lamps. For information about these characteristics, see the data sheets of the equivalent Subminiature lamp.

Package Dimensions



NOTE: ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).

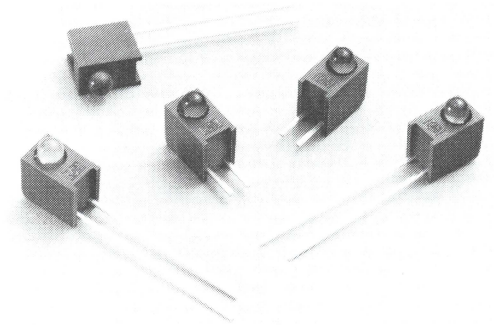
HEWLETT PACKARD

T-1 (3mm) RIGHT ANGLE LED INDICATORS

OPTION - 010
OPTION - 101

Features

- **IDEAL FOR CARD EDGE STATUS INDICATION**
- **PACKAGE DESIGN ALLOWS FLUSH SEATING ON A PC BOARD**
- **MAY BE SIDE STACKED ON 4.57 mm (0.18 in) CENTERS**
- **UP TO 8 UNITS MAY BE COUPLED FOR A HORIZONTAL ARRAY CONFIGURATION WITH A COMMON COUPLING BAR (SEE T-1 RIGHT ANGLE ARRAY DATA SHEET)**
- **LEDs AVAILABLE IN ALL LED COLORS, WITH OR WITHOUT INTEGRATED CURRENT LIMITING RESISTOR IN T-1 PACKAGES**
- **EASY FLUX REMOVAL DESIGN**
- **HOUSING MATERIAL MEETS UL 94V-0 RATING**
- **ADDITIONAL CATALOG LAMPS AVAILABLE AS OPTIONS**



Description

Hewlett-Packard T-1 Right Angle Indicators are industry standard status indicators that incorporate a tinted diffused T-1 LED lamp in a black plastic housing. The indicators are available in Standard Red, High Efficiency Red, Orange, Yellow, and High Performance Green, with or without an integrated current limiting resistor. These products are designed to be used as back panel diagnostic indicators and card edge logic status indicators.

Ordering Information

To order other T-1 High Dome Lamps in Right Angle Housings in addition to the parts indicated above, select the base part number and add the option code 010 or 101, depending on the lead length desired (see drawing below).

For example, by ordering HLMP-1302-010, you would receive the long lead option. By ordering HLMP-1302-101, you would receive the short lead option.

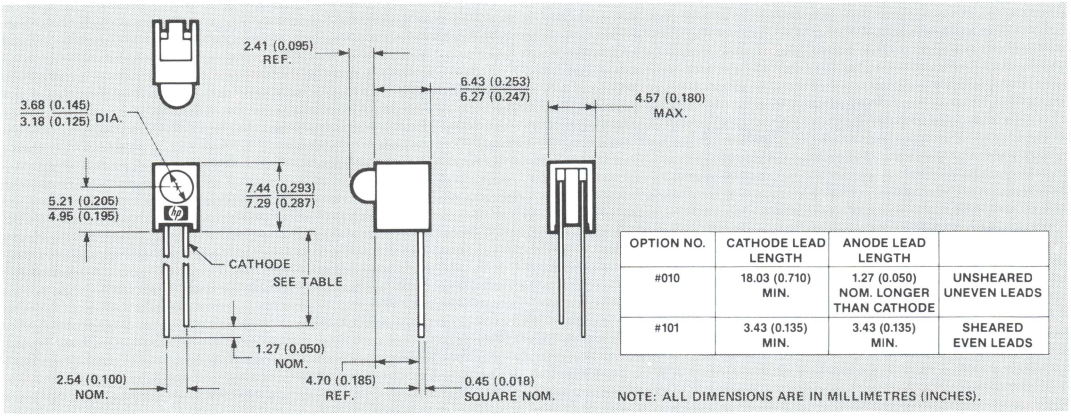
Arrays made by connecting two to eight single Right Angle Indicators with a Common Coupling Bar are available. Ordering information for arrays may be found on the T-1 Right Angle Array data sheet.

The above data sheet information is for the most commonly ordered part numbers. Refer to other T-1 base part number specifications in this catalog for other lamp types that may be ordered with the right angle option.

Absolute Maximum Ratings and Other Electrical/Optical Characteristics

The absolute maximum ratings and typical device characteristics are identical to those of the T-1 LED lamps. For information about these characteristics, see the data sheets of the equivalent T-1 LED lamp.

Package Dimensions



OPTION NO.	CATHODE LEAD LENGTH	ANODE LEAD LENGTH	
#010	18.03 (0.710) MIN.	1.27 (0.050) NOM. LONGER THAN CATHODE	UNSHEARED UNEVEN LEADS
#101	3.43 (0.135) MIN.	3.43 (0.135) MIN.	SHEARED EVEN LEADS

NOTE: ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).

SOLID STATE LAMPS

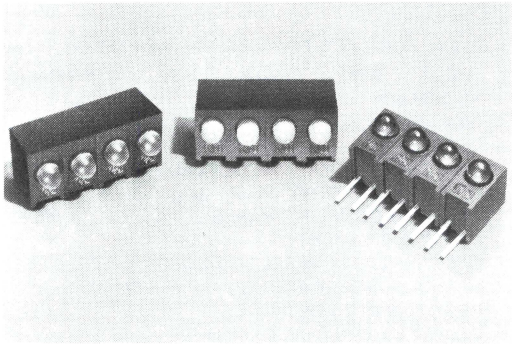
HEWLETT PACKARD

T-1 (3 mm) RIGHT ANGLE ARRAYS

OPTION:
102 104 106 108
103 105 107

Features

- **IDEAL FOR PC BOARD STATUS INDICATION**
- **STANDARD 4 ELEMENT CONFIGURATION**
- **EASY HANDLING**
- **EASY FLUX REMOVAL**
- **HOUSING MEETS UL 94V-O FLAMMABILITY SPECIFICATIONS**
- **OTHER CATALOG LAMPS AVAILABLE**



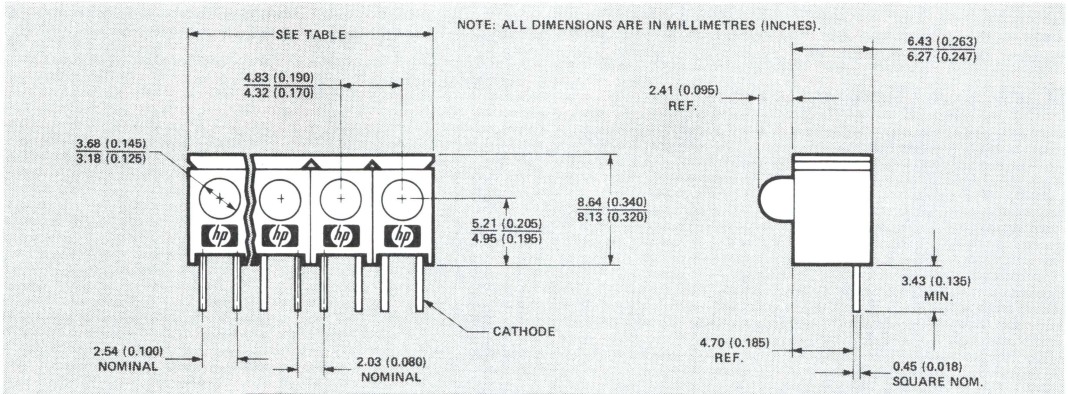
Description

These T-1 right angle arrays incorporate standard T-1 lamps for a good balance of viewing angle and intensity. Single units are held together by a plastic tie bar. The leads of each member of the array are spaced on 2.54 mm (0.100 in) centers. Lead spacing between adjacent lamps in the array is on 2.03 mm (0.080 in) centers. These products are designed to be used as back panel diagnostic indicators and logic status indicators on PC boards.

Ordering Information

Use the option code 102 through 108 in addition to the base part number to order these arrays. Arrays from 2 to 8 elements in length and special lamp color combinations within an array are available. Please contact your nearest Hewlett-Packard Components representative for ordering information on these special items.

Package Dimensions



OPTION NO.	ARRAY LENGTH	OPTION NO.	ARRAY LENGTH	OPTION NO.	ARRAY LENGTH
#102	9.65 (0.380) 8.79 (0.346)	#105	23.14 (0.911) 22.73 (0.895)	#108	36.70 (1.445) 36.45 (1.435)
#103	14.22 (0.560) 13.36 (0.526)	#106	27.71 (1.091) 27.31 (1.075)		
#104	18.57 (0.731) 18.16 (0.715)	#107	32.28 (1.271) 31.88 (1.255)		

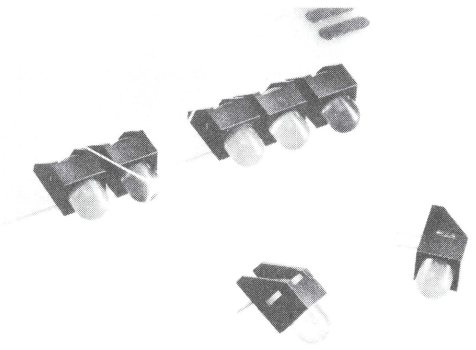
HEWLETT PACKARD

LED RIGHT ANGLE INDICATORS T-1 3/4 (5mm)

OPTION - 010
OPTION - 101

Features

- **IDEAL FOR CARD EDGE STATUS INDICATION**
- **PACKAGE DESIGN ALLOWS FLUSH SEATING ON A PC BOARD**
- **MAY BE SIDE STACKED ON 6.35 mm (0.25") CENTERS**
- **LEDs AVAILABLE IN FOUR COLORS, WITH OR WITHOUT INTEGRATED CURRENT LIMITING RESISTOR IN T-1 3/4 TINTED DIFFUSED PACKAGES**
- **ADDITIONAL CATALOG LAMPS AVAILABLE AS OPTIONS**



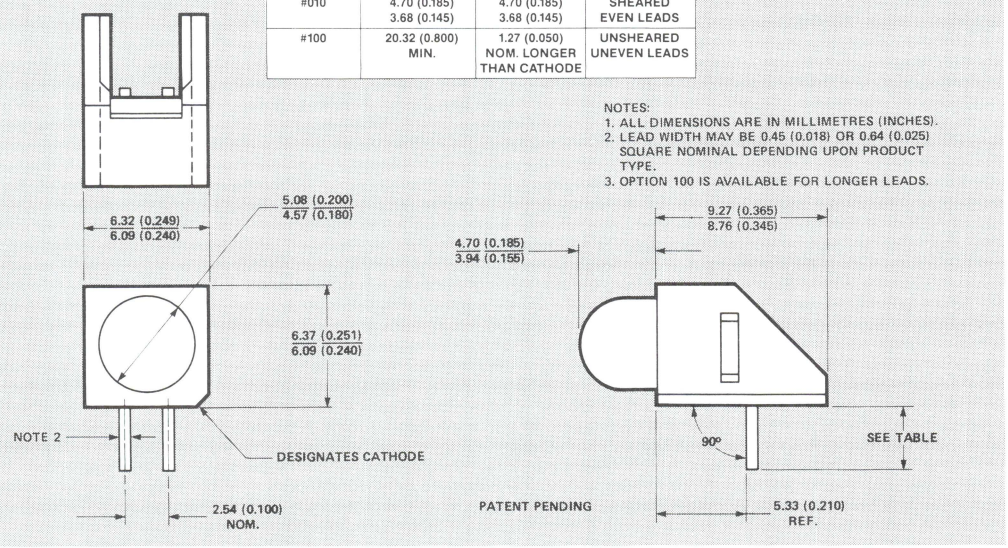
Description

The T-1 3/4 Option 010 and 100 series of Right Angle Indicators are industry standard status indicators that incorporate a tinted diffused T-1 3/4 LED lamp in a black plastic housing. The indicators are available in standard Red, High Efficiency Red, Yellow, or High Performance Green with or without an integrated current limiting resistor. These products are designed to be used as back panel diagnostic indicators and card edge logic status indicators.

Package Dimensions

OPTION NO.	CATHODE LEAD LENGTH	ANODE LEAD LENGTH	
#010	4.70 (0.185) 3.68 (0.145)	4.70 (0.185) 3.68 (0.145)	SHEARED EVEN LEADS
#100	20.32 (0.800) MIN.	1.27 (0.050) NOM. LONGER THAN CATHODE	UNSHEARED UNEVEN LEADS

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. LEAD WIDTH MAY BE 0.45 (0.018) OR 0.64 (0.025) SQUARE NOMINAL DEPENDING UPON PRODUCT TYPE.
3. OPTION 100 IS AVAILABLE FOR LONGER LEADS.



SOLID STATE LAMPS

Ordering Information

To order T-1 3/4 high dome lamps in addition to the parts indicated above, select the base part number and add the option code 010 or 100. For example: HLMP-3750-010.

All Hewlett-Packard T-1 3/4 high-dome lamps are available in right angle housing. Contact your local Hewlett-Packard Sales Office or authorized components distributor for additional ordering information.

Absolute Maximum Ratings and Electrical/Optical Characteristics

The absolute maximum ratings and device characteristics are identical to those of the T-1 3/4 LED lamps. For information about these characteristics, see the data sheets of the equivalent T-1 3/4 LED lamp.

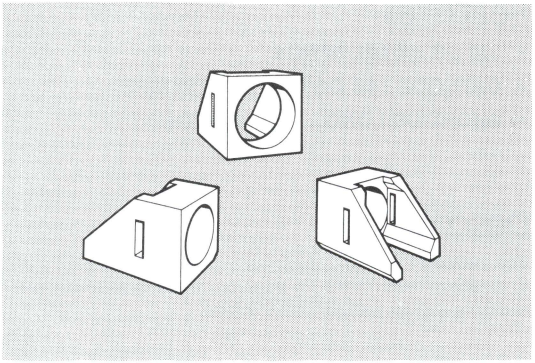
HEWLETT PACKARD

T-1 3/4 LED LAMP RIGHT ANGLE HOUSING

HLMP-5029

Features

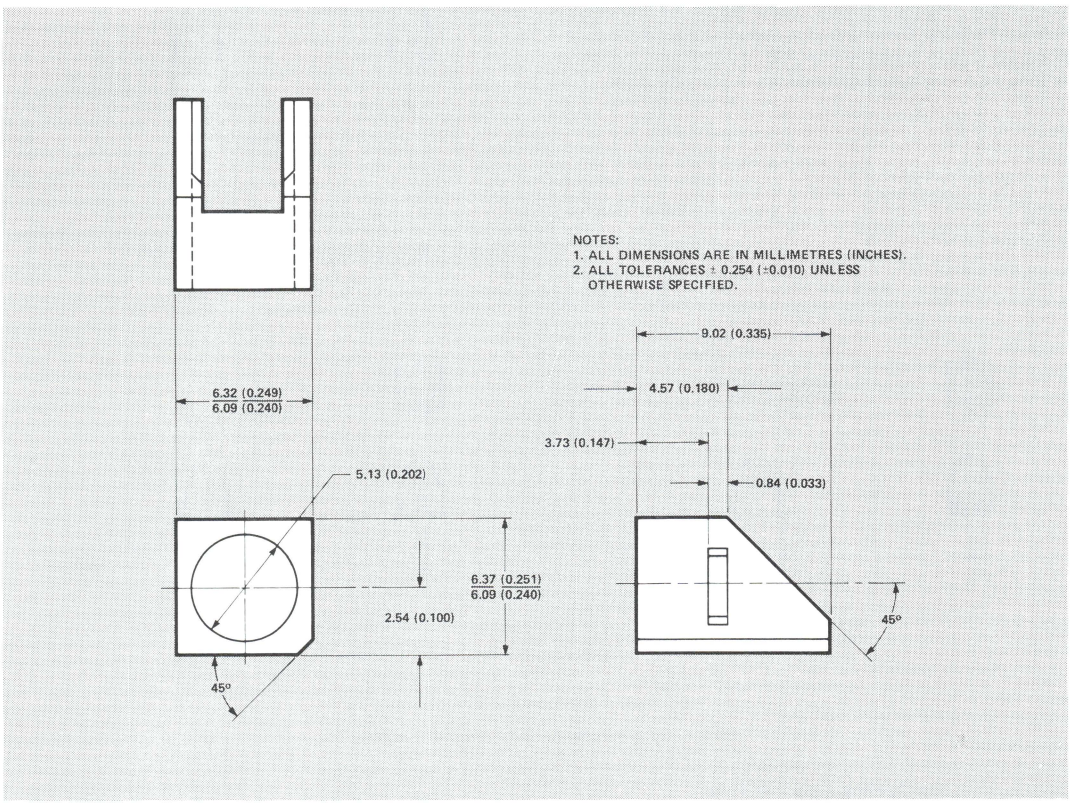
- **FITS ANY HP HIGH DOME T-1 3/4 LED LAMP**
- **SNAP-IN FIT MAKES MOUNTING SIMPLE**
- **HIGH CONTRAST BLACK PLASTIC**



Description

The HLMP-5029 is a black plastic right angle housing which mates with any Hewlett-Packard High Dome T-1 3/4 lamp. The lamp snaps into place. The material is fully compatible with environmental specifications of all Hewlett-Packard T-1 3/4 lamps.

Physical Dimensions



SOLID STATE LAMPS

HEWLETT PACKARD

OPTIONAL LEADFORMS FOR HP SUBMINIATURE LAMPS

Features

- 100 OR 200 MIL BENDS
- CATHODE TAB OR CATHODE STRIPE
- SHORT OR LONG LEAD LENGTH

Description

The Hewlett-Packard Subminiature Lamps are available in a variety of lead forms. In addition, these lead forms are available with or without cathode tabs.

Ordering Information

To obtain subminiature lamps with these lead forms, contact your local Hewlett-Packard sales office or franchised Hewlett-Packard Distributor for specific ordering instructions. Be sure to specify either .100" or .200" spacing, short or long lead length, and cathode tab or cathode stripe.

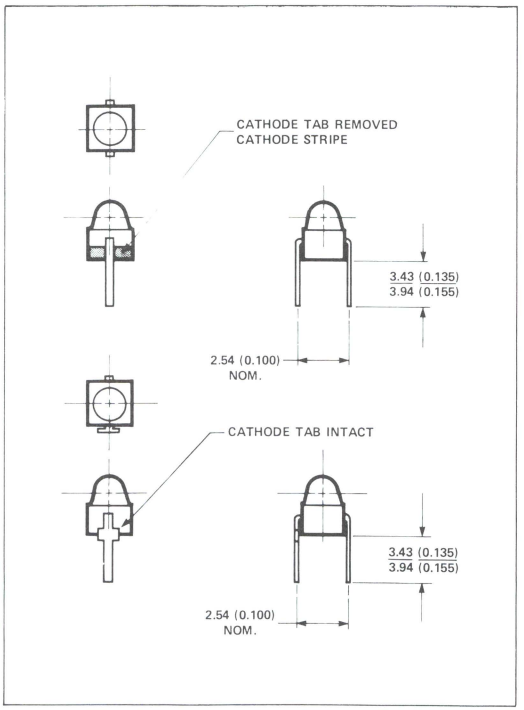


Figure 1. 0.100" Lead Spacing, Short Lead Length

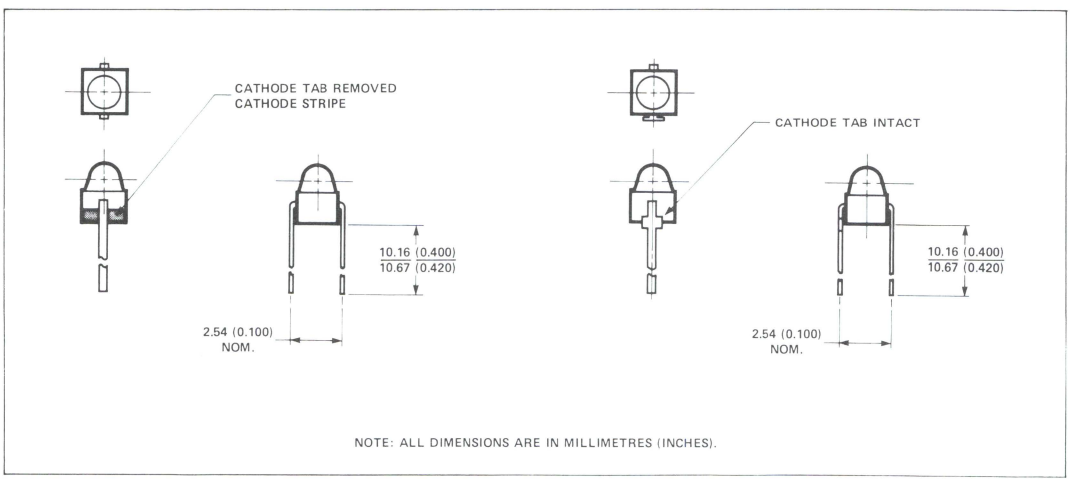


Figure 2. 0.100" Lead Spacing, Long Lead Length

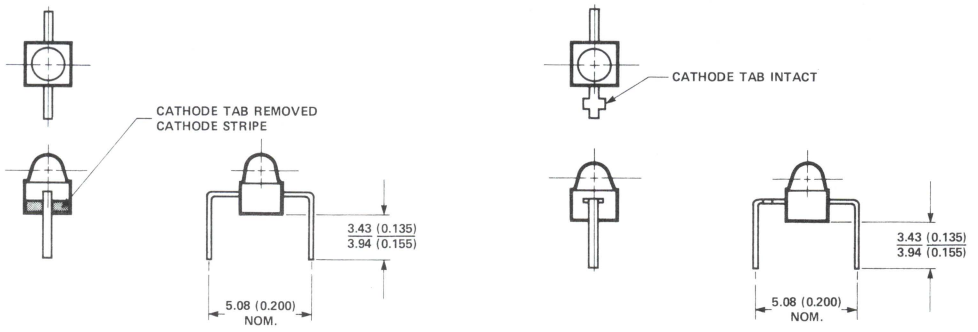
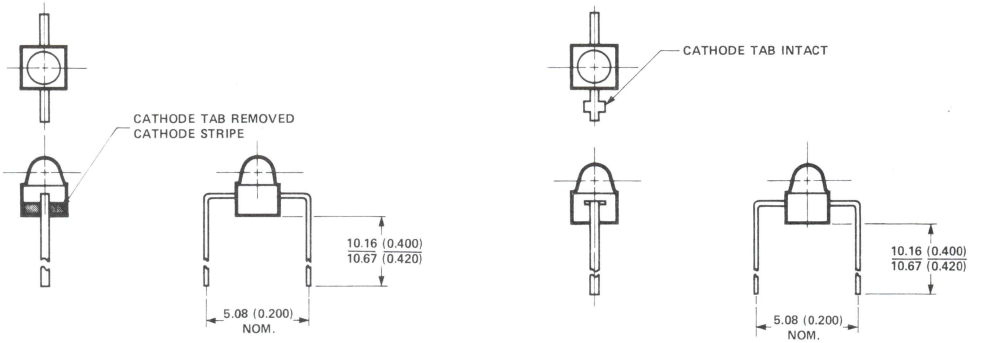


Figure 3. 0.200" Lead Spacing, Short Lead Length



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. REFER TO THE SPECIFIC DATA SHEET FOR SUBMINIATURE LAMPS FOR THE DETAILED DIMENSIONS OF THE LAMP.

Figure 4. 0.200" Lead Spacing, Long Lead Length

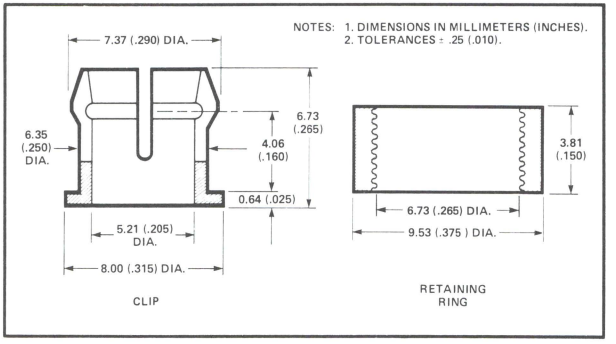
HEWLETT PACKARD

CLIP AND RETAINING RING FOR PANEL MOUNTED T1 3/4 LEDs

OPTION 009 (HLMP-0103)

Description

The Option 009 (HLMP-0103) is a black plastic mounting clip and retaining ring. It is designed to panel mount Hewlett-Packard Solid State high profile T-1 3/4 size lamps. This clip and ring combination is intended for installation in instrument panels from 1.52mm (.060") to 3.18mm (.125") thick. For panels greater than 3.18mm (.125") counterboring is required to the 3.18mm (.125") thickness.



Mounting Instructions

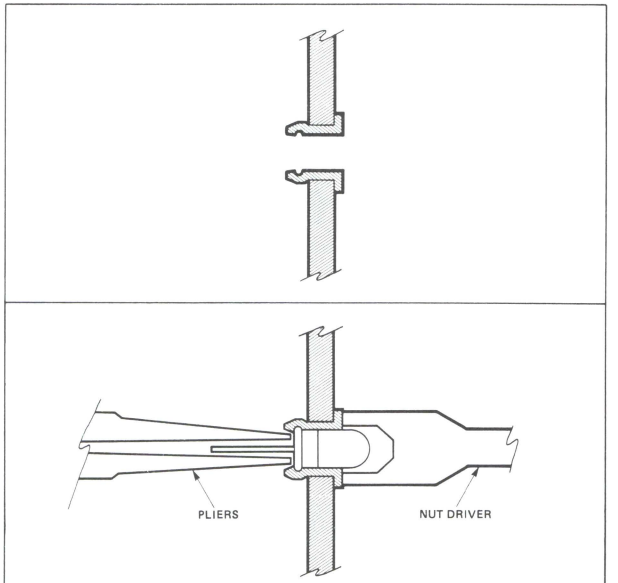
1. Drill an ASA C size 6.15mm (.242") dia. hole in the panel. Deburr but do not chamfer the edges of the hole.

2. Press the panel clip into the hole from the front of the panel.

3. Press the LED into the clip from the back. Use blunt long nose pliers to push on the LED. Do not use force on the LED leads. A tool such as a nut driver may be used to press on the clip.

Note: Clip and retaining ring are also available for T-1 package, from a non-HP source. Please contact Interconsal Association, 991 Commercial St., Palo Alto, CA 94303 for additional information.

4. Slip a plastic retaining ring onto the back of the clip and press tight using tools such as two nut drivers.



Ordering Information

T-1 3/4 High Dome LED Lamps can be purchased to include clip and ring by adding Option Code 009 to the device catalog part number.

Example:

To order the HLMP-3300 including clip and ring, order as follows: HLMP-3300 Option 009.

Hermetic Lamps

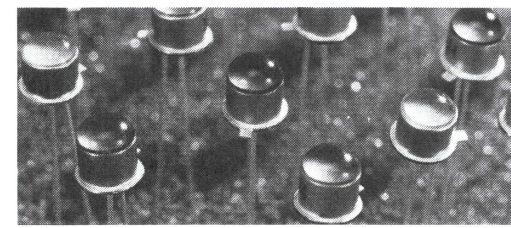
HEWLETT PACKARD

JAN QUALIFIED HERMETIC SOLID STATE LAMPS*

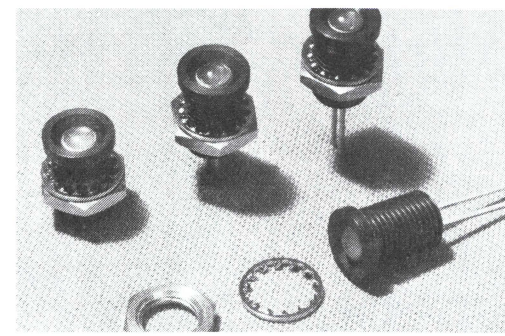
1N5765 JAN1N5765 JANTX1N5765	1N6093 JAN1N6093 JANTX1N6093
1N6092 JAN1N6092 JANTX1N6092	1N6094 JAN1N6094 JANTX1N6094

Features

- **MILITARY QUALIFIED LISTED ON MIL-S-19500QPL**
- **CHOICE OF 4 COLORS**
  - **Red**
  - **High Efficiency Red**
  - **Yellow**
  - **Green**
- **DESIGNED FOR HIGH-RELIABILITY APPLICATIONS**
- **HERMETICALLY SEALED**
- **WIDE VIEWING ANGLE**
- **LOW POWER OPERATION**
- **IC COMPATIBLE**
- **LONG LIFE**
- **TWO PANEL MOUNT OPTIONS[4]**
  - **Option 001**
    - **Aluminum Black Anodized Sleeve**
  - **Option 002**
    - **Black Conductive Composite Sleeve**
    - **Both Options Have Wire Wrappable Leads Electrically Isolated From The Sleeve**



HERMETIC TO-46 LAMP



LAMP ASSEMBLY AS PANEL MOUNT

Description

The 1N5765, 1N6092, 1N6093 and 1N6094 solid state LED's are hermetically sealed in a TO-46 package with a tinted, diffused plastic lens over a glass window. The panel mountable versions consist of an LED unit permanently mounted in a conductive composite or anodized aluminum sleeve. The electrically conductive composite sleeve provides electrical contact to the front and back panels and has RFI shielding equivalent to the aluminum sleeve. Additionally, the composite sleeve has excellent tensil strength and superior scratch and wear resistance. All these devices are designed for high reliability applications and provide excellent on-off contrast, high axial luminous intensity and a wide viewing angle.

The 1N5765 utilizes a GaAsP LED chip with a red diffused lens over a glass window.

The 1N6092 has a high efficiency red GaAsP on GaP LED chip with a red diffused lens over a glass window. This device is comparable to the 1N5765 but it's efficiency extends to higher currents and it provides greater luminous intensity.

The 1N6093 provides a yellow GaAsP on GaP LED chip with a yellow, diffused lens over a glass window.

The 1N6094 utilizes a green GaP LED chip with a green, diffused lens over a glass window.

The plastic lens over glass window system is extremely durable and has exceptional temperature cycling capabilities.

*Panel mount versions of all of the above are available per the selection matrix on the next page.

COLOR — PART NUMBER — LAMP AND PANEL MOUNT MATRIX				
Description	Standard Product	With JAN Qualification[1]	JAN Plus TX Testing[2]	Controlling MIL-S-19500 Document[5]
TABLE I HERMETIC TO-46 PART NUMBER SYSTEM				
Standard Red	1N5765	JAN1N5765	JANTX1N5765	/467
High Efficiency Red	1N6092	JAN1N6092	JANTX1N6092	/519
Yellow	1N6093	JAN1N6093	JANTX1N6093	/520
Green	1N6094	JAN1N6094	JANTX1N6094	/521
TABLE II PANEL MOUNTABLE PART NUMBER SYSTEM[3,4]				
Standard Red	HLMP-0904	HLMP-0930 ——	HLMP-0931 ——	NONE
High Efficiency Red	HLMP-0354	HLMP-0380 (JANM19500/51901)	HLMP-0381 (JTXM19500/51902)	/519
Yellow	HLMP-0454	HLMP-0480 (JANM19500/52001)	HLMP-0481 (JTXM19500/52002)	/520
Green	HLMP-0554	HLMP-0580 (JANM19500/52101)	HLMP-0581 (JTXM19500/52102)	/521

Notes:
1. Parts are marked J1NXXXX or as indicated.
2. Parts are marked JTX1NXXXX or as indicated.
3. Panel mountable packaging incorporates additional assembly of the equivalent Table I TO-46 part into the panel mount enclosure. The resulting part is then marked per Table II.
4. When ordering panelmount devices, specify either Option #001 (anodized aluminum sleeve) or Option #002 (conductive composite sleeve).
5. JAN and JANTX parts only.

JAN PART: Samples of each lot are subjected to Group A and B tests listed below. Every six months, samples from a single lot of each part type are subjected to Group C testing. All tests are to the conditions and limits specified by the appropriate MIL-S-19500 slash sheet.

Examination or Test	MIL-STD-750 Method
GROUP A INSPECTION	
Subgroup 1	
Visual and mechanical examination	2071
Subgroup 2	
Luminous intensity ($\theta = 0°$)	—
Luminous intensity ($\theta = 30°$)	—
Reverse current	4016
Forward voltage	4011
Subgroup 3	
Capacitance	4001
GROUP B INSPECTION	
Subgroup 1	
Physical dimensions	2066
Subgroup 2	
Solderability	2026
Thermal shock (temperature cycling)	1051
Thermal shock (glass strain)	1056
Hermetic seal	1071
Moisture resistance	1021
End points: Luminous intensity ($\theta = 0°$)	—
Subgroup 3	
Shock	2016
Vibration, variable frequency	2056
Constant acceleration	2006
End points: (same as subgroup 2)	
Subgroup 4	
Terminal strength	2036
End points: Hermetic seal	1071
Subgroup 5	
Salt atmosphere (corrosion)	1041
Subgroup 6	
High-temperature life (nonoperating)	1032
End points: Luminous intensity ($\theta = 0°$)	—
Subgroup 7	
Steady-state operation life	1027
End points: (same as subgroup 6)	

JANTX PART: These devices undergo 100% screening tests as listed below to the conditions and limits specified by the MIL-S-19500 slash sheet. The JANTX lot has also been subjected to Group A, B and C tests as for the JAN PART above.

Examination or Test	MIL-STD-750 Method
GROUP C INSPECTION	
Subgroup 1	
Thermal shock (temperature cycling)	1051
End points: (same as subgroup 2 of group B)	
Subgroup 2	
Resistance to solvents	—
Subgroup 3	
High-temperature life (nonoperating)	1031
End points: Luminous intensity ($\theta = 0°$)	—
Subgroup 4	
Steady-state operation life	1026
End points: (same as subgroup 3)	
Subgroup 5	
Peak forward pulse current (transient)	—
End points: (same as subgroup 6 of group B)	
Subgroup 6	
Peak forward pulse current (operating)	—
End points: (same as subgroup 6 of group B)	
PROCESS AND POWER CONDITION ("TX" types only)	
High temperature storage (nonoperating)	—
Thermal shock (temperature cycling)	1051
Constant acceleration	2006
Hermetic seal	1071
Luminous intensity ($\theta = 0°$)	—
Forward voltage	4011
Reverse current	4016
Burn-in (Forward bias)	—
End points (within 72 hours of burn-in):	
Δ Luminous intensity ($\theta = 0°$)	—
Δ Forward voltage	4011

Absolute Maximum Ratings at T_A=25°C

Parameter	Red HLMP-0904	High Eff. Red HLMP-0354	Yellow HLMP-0454	Green HLMP-0554	Units
Power Dissipation (derate linearly from 50°C at 1.6mW/°C)	100	120	120	120	mW
DC Forward Current	50[1]	35[2]	35[2]	35[2]	mA
Peak Forward Current	1000 See Fig. 5	60 See Fig. 10	60 See Fig. 15	60 See Fig. 20	mA
Operating and Storage Temperature Range	-65°C to 100°C				
Lead Soldering Temperature [1.6mm (0.063 in.) from body]	260°C for 7 seconds.				

Notes: 1. Derate from 50°C at 0.2mA/°C 2. Derate from 50°C at 0.5mA/°C

Electrical/Optical Characteristics at T_A=25°C

Symbol	Description	HLMP-0904			HLMP-0354			HLMP-0454			HLMP-0554			Units	Test Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{V1}	Axial Luminous Intensity	0.5	1.0		3.0	8.0		3.0	8.0		3.0	8.0		mcd	I_F = 20mA Figs. 3,8,13,18 θ = 0°
											At I_F = 25mA				
I_{V2}	Luminous Intensity at θ = 30°[5]	1.5			1.5			1.5			1.5			mcd	I_F = 20 mA θ = 30°
$2\Theta_{1/2}$	Included Angle Between Half Luminous Intensity Points		60			70			70			70		deg.	[1] Figures 6, 11, 16, 21
λ_{PEAK}	Peak Wavelength[5]	630	655	700	590	635	695	550	583	660	525	565	600	nm	Measurement at Peak
λ_d	Dominant Wavelength		640			626			585			570		nm	[2]
τ_S	Speed of Response		10			200			200			200		ns	
C	Capacitance[5]		200	300		35	100		35	100		35	100	pF	V_f=0; f=1 MHz
Θ_{JC}	Thermal Resistance*		425			425			425			425		°C/W	[3]
Θ_{JC}	Thermal Resistance**		550			550			550			550		°C/W	[3]
V_F	Forward Voltage		1.6	2.0		2.0	3.0		2.0	3.0		2.1	3.0	V	I_F = 20mA Figures 2, 7, 12, 17
												At I_F = 25mA			
I_R	Reverse Current[5]			1.0			1.0			1.0			1.0	μA	V_R = 3V
BV_R	Reverse Breakdown Voltage	4	5		5.0			5.0			5.0			V	I_R = 100μA
η_v	Luminous Efficacy		56			140			455			600		lm/W	[4]

NOTES:

1. $\Theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Junction to Cathode Lead with 3.18mm (0.125 inch) of leads exposed between base of flange and heat sink.
4. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_v/\eta_v$, where I_v is the luminous intensity in candelas and η_v is the luminous efficacy in lumens/watt.
5. Limits do not apply to non JAN or JANTX parts.

*Panel mount.

**T0-46

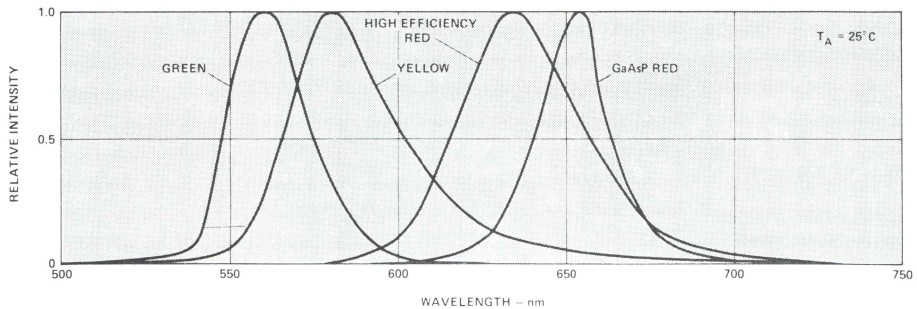
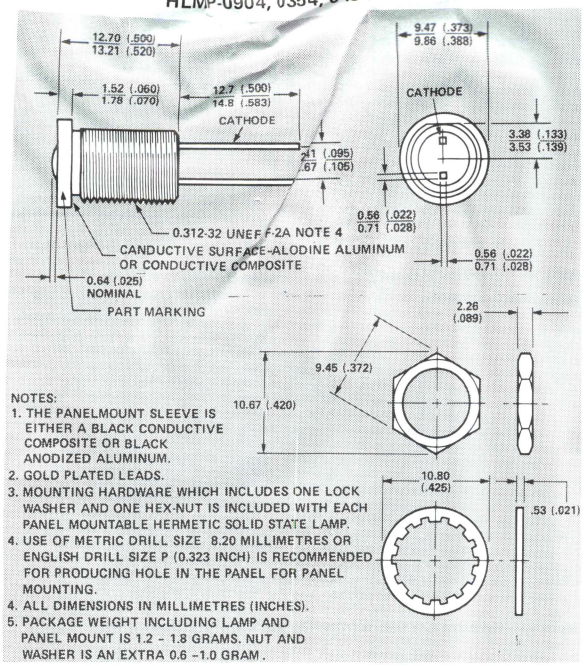


Figure 1. Relative Intensity vs. Wavelength.

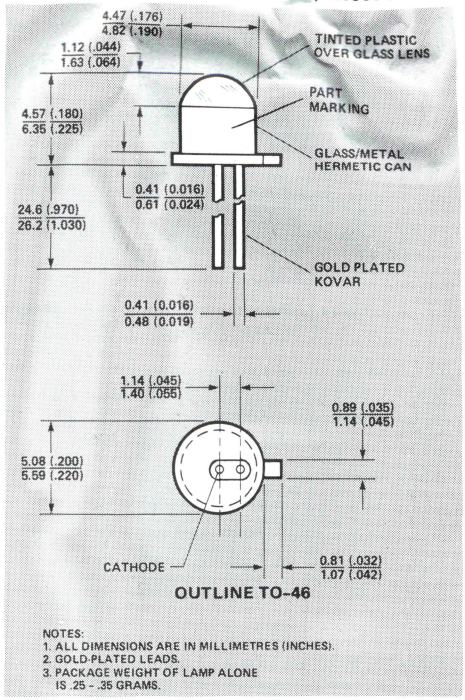
Package Dimensions

HLMP-0904, 0354, 0454 0554



NOTES:
1. THE PANELMOUNT SLEEVE IS EITHER A BLACK CONDUCTIVE COMPOSITE OR BLACK ANODIZED ALUMINUM.
2. GOLD PLATED LEADS.
3. MOUNTING HARDWARE WHICH INCLUDES ONE LOCK WASHER AND ONE HEX-NUT IS INCLUDED WITH EACH PANEL MOUNTABLE HERMETIC SOLID STATE LAMP.
4. USE OF METRIC DRILL SIZE 8.20 MILLIMETRES OR ENGLISH DRILL SIZE P (0.323 INCH) IS RECOMMENDED FOR PRODUCING HOLE IN THE PANEL FOR PANEL MOUNTING.
4. ALL DIMENSIONS IN MILLIMETRES (INCHES).
5. PACKAGE WEIGHT INCLUDING LAMP AND PANEL MOUNT IS 1.2 - 1.8 GRAMS. NUT AND WASHER IS AN EXTRA 0.6 -1.0 GRAM.

1N5765, 1N6092, 1N6093, 1N6094



OUTLINE TO-46

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. GOLD-PLATED LEADS.
3. PACKAGE WEIGHT OF LAMP ALONE IS .25 - .35 GRAMS.

Family of Red 1N5765/HLMP-0904

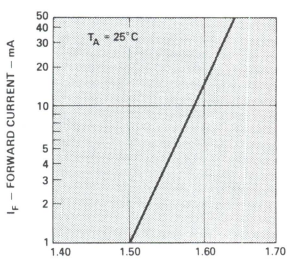


Figure 2. Forward Current vs. Forward Voltage.

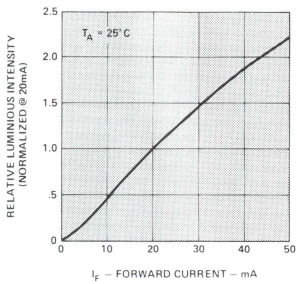


Figure 3. Relative Luminous Intensity vs. Forward Current.

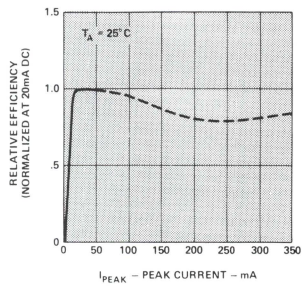


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

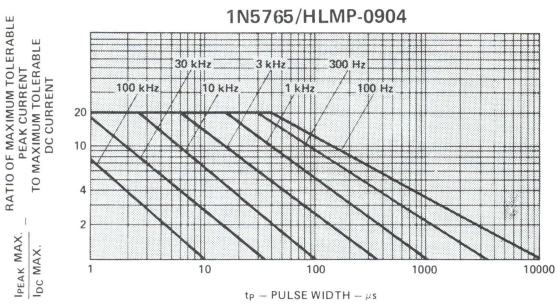


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

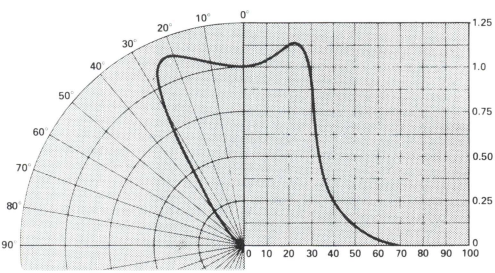


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

SOLID STATE LAMPS

HERMETIC LAMPS

Family of High Efficiency

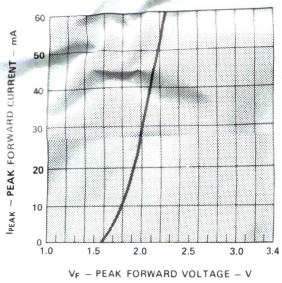


Figure 7. Forward Current vs. Forward Voltage.

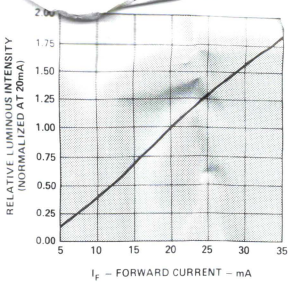


Figure 8. Relative Luminous Intensity vs. Forward Current.

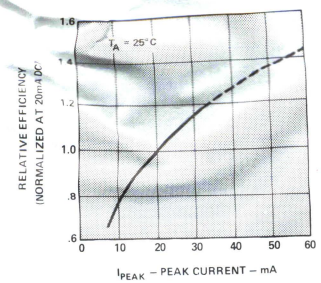


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

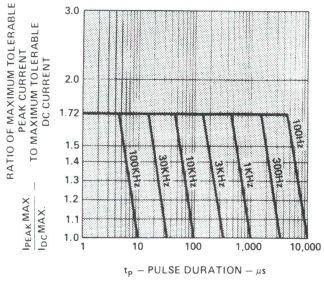


Figure 10. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

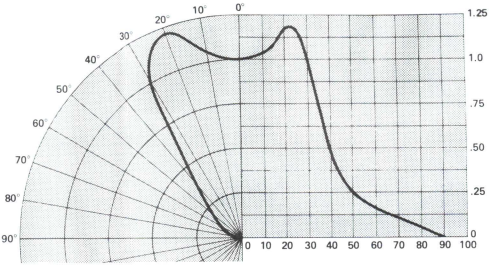


Figure 11. Relative Luminous Intensity vs. Angular Displacement.

Family of Yellow 1N6093/HLMP-0454

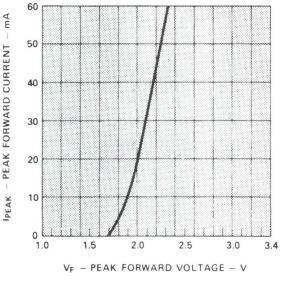


Figure 12. Forward Current vs. Forward Voltage.

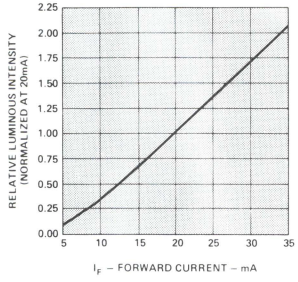


Figure 13. Relative Luminous Intensity vs. Forward Current.

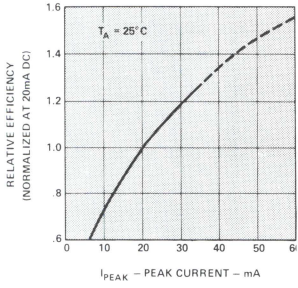


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

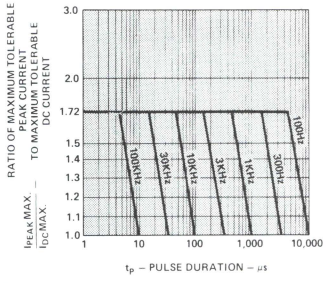


Figure 15. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

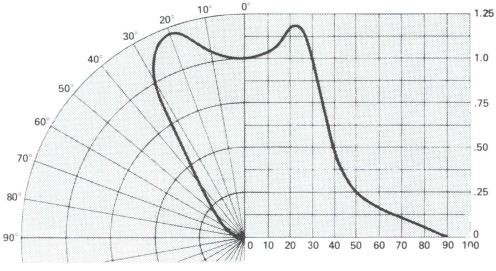


Figure 16. Relative Luminous Intensity vs. Angular Displacement.

Family of Green 1N6094/HLMP-0554

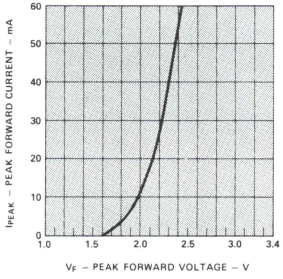


Figure 17. Forward Current vs. Forward Voltage.

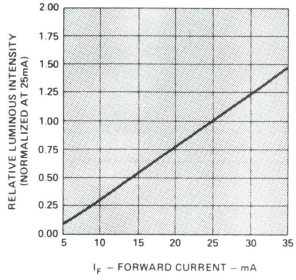


Figure 18. Relative Luminous Intensity vs. Forward Current.

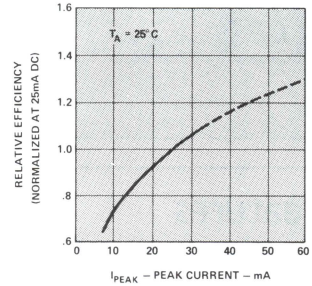


Figure 19. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

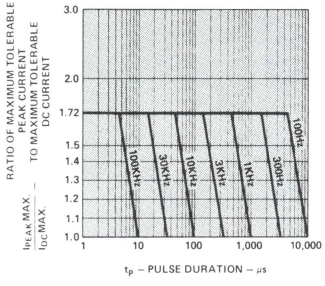


Figure 20. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

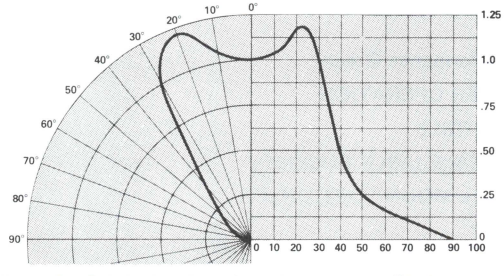


Figure 21. Relative Luminous Intensity vs. Angular Displacement.

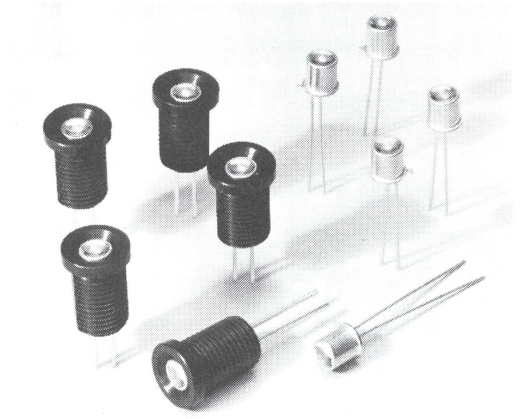
HEWLETT PACKARD

ULTRA-BRIGHT HERMETIC SOLID STATE LAMPS*

HLMP-0363 HLMP-0463 HLMP-0563
HLMP-0391 HLMP-0491 HLMP-0591
HLMP-0392 HLMP-0492 HLMP-0592

Features

- **SUNLIGHT VIEWABLE WITH PROPER CONTRAST ENHANCEMENT FILTER**
- **HERMETICALLY SEALED**
- **CHOICE OF 3 COLORS**
  - **High Efficiency Red**
  - **Yellow**
  - **High Performance Green**
- **LOW POWER OPERATION**
- **IC COMPATIBLE**
- **LONG LIFE/RELIABLE/RUGGED**
- **TWO PANEL MOUNT OPTIONS[2]**
  - **Option 001**
    - **Aluminum Black Anodized Sleeve**
  - **Option 002**
    - **Black Conductive Composite Sleeve**
    - **Both Options Have Wire Wrappable Leads**
    - **Electically Isolated From The Sleeve**



Description

The HLMP-0363, HLMP-0463, and HLMP-0563 are hermetically sealed solid state lamps in a TO-18 package with a clear glass lens. These hermetic lamps provide improved brightness over conventional hermetic LED lamps, excellent on-off contrast, and high axial luminous intensity. These LED indicators are designed for use in applications requiring readability in bright sunlight. With a proper contrast enhancement filter, these LED indicators are readable in sunlight ambients. All of these devices are available in a choice of two panel mountable fixtures, a conductive composite or anodized aluminum.

The HLMP-0363 utilizes a high efficiency red GaAsP on GaP LED chip. The HLMP-0463 uses a yellow GaAsP on a GaP LED chip. The HLMP-0563 uses a green GaP LED chip.

These devices are offered with JAN equivalent quality conformance inspection (QCI) and JANTX equivalent screenings similar to MIL-S-19500/519/520/521.

*Panel Mount version of all of the above are available per the selection matrix on this page.

COLOR — PART NUMBER — LAMP AND PANEL MOUNT MATRIX			
Description	**Standard Product**	**JAN QCI**	**JANTX Equivalent**
TABLE I HERMETIC TO-18 PART NUMBER SYSTEM			
High Efficiency Red	HLMP-0363	HLMP-0391	HLMP-0392
Yellow	HLMP-0463	HLMP-0491	HLMP-0492
Green	HLMP-0563	HLMP-0591	HLMP-0592
TABLE II PANEL MOUNTABLE PART NUMBER SYSTEM[1,2]			
High Efficiency Red	HLMP-0364	HLMP-0365	HLMP-0366
Yellow	HLMP-0464	HLMP-0465	HLMP-0466
Green	HLMP-0564	HLMP-0565	HLMP-0566

NOTE:

1. Panel mountable packaging incorporates additional assembly of the equivalent Table I TO-18 part into the panel mount enclosure. The resulting part is then marked per Table II.
2. When ordering panelmount devices, specify either Option #001 (anodized aluminum sleeve) or Option #002 (conductive composite sleeve).

JAN Equivalent: Samples of each lot are subjected to Group A and B, listed below. Every six months samples from a single lot of each part type are subjected to Group C testing. All tests are to the conditions and limits specified by the equivalent MIL-S-19500 slash sheet for the device under test.

JANTX Equivalent: These devices undergo 100% screening tests as listed below to the conditions and limits specified by MIL-S-19500 slash sheet. The JANTX lot has also been subjected to Group A, B and C tests as for the JAN Equivalent PART above.

Examination or Test	MIL-STD-750 Method
GROUP A INSPECTION	
Subgroup 1	
Visual and mechanical examination	2071
Subgroup 2	
Luminous intensity ($\theta = 0°$)	—
Reverse current	4016
Forward voltage	4011
Subgroup 3	
Capacitance	4001
GROUP B INSPECTION	
Subgroup 1	
Physical dimensions	2066
Subgroup 2	
Solderability	2026
Thermal shock (temperature cycling)	1051
Thermal shock (glass strain)	1056
Hermetic seal	1071
Moisture resistance	1021
End points: Luminous intensity ($\theta = 0°$)	—
Subgroup 3	
Shock	2016
Vibration, variable frequency	2056
Constant acceleration	2006
End points: (same as subgroup 2)	
Subgroup 4	
Terminal strength	2036
End points: Hermetic seal	1071
Subgroup 5	
Salt atmosphere (corrosion)	1041
Subgroup 6	
High-temperature life (nonoperating)	1032
End points: Luminous intensity ($\theta = 0°$)	—
Subgroup 7	
Steady-state operation life	1027
End points: (same as subgroup 6)	

Examination or Test	MIL-STD-750 Method
GROUP C INSPECTION	
Subgroup 1	
Thermal shock (temperature cycling)	1051
End points: (same as subgroup 2 of group B)	
Subgroup 2	
Resistance to solvents	—
Subgroup 3	
High-temperature life (nonoperating)	1031
End points: Luminous intensity ($\theta = 0°$)	—
Subgroup 4	
Steady-state operation life	1026
End points: (same as subgroup 3)	
Subgroup 5	
Peak forward pulse current (transient)	—
End points: (same as subgroup 6 of group B)	
Subgroup 6	
Peak forward pulse current (operating)	—
End points: (same as subgroup 6 of group B)	
PROCESS AND POWER CONDITION ("TX" types only)	
High temperature storage (nonoperating)	—
Thermal shock (temperature cycling)	1051
Constant acceleration	2006
Hermetic seal	1071
Luminous intensity ($\theta = 0°$)	—
Forward voltage	4011
Reverse current	4016
Burn-in (Forward bias)	—
End points (within 72 hours of burn-in):	
Δ Luminous intensity ($\theta = 0°$)	—
Δ Forward voltage	4011

Absolute Maximum Ratings at T_A=25° C

Parameter	High Eff. Red HLMP-0363	Yellow HLMP-0463	Green HLMP-0563	Units
Power Dissipation (derate linearly from 50° C at 1.6mW/° C)	120	120	120	mW
DC Forward Current	35[1]	35[1]	35[1]	mA
Peak Forward Current	60 See Fig. 5	60 See Fig. 10	60 See Fig. 15	mA
Operating and Storage Temperature Range	-65° C to 100° C			
Lead Soldering Temperature [1.6mm (0.063 in.) from body]	260° C for 7 seconds.			

NOTES: 1. Derate from 50° C at 0.5mA/° C

Electrical/Optical Characteristics at T_A=25° C

Symbol	Description	HLMP-0363			HLMP-0463			HLMP-0563			Units	Test Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
I_{V1}	Axial Luminous Intensity	20	50		20	50		20	50		mcd	I_F = 20mA Figs. 3,8,13 θ = 0°
									At I_F = 25mA			
$2\Theta_{1/2}$	Included Angle Between Half Luminous Intensity Points		18			18			18		deg.	[1] Figures 6,11,16
λ_{PEAK}	Peak Wavelength	590	635	695	550	583	660	525	565	600	nm	Measurement at Peak
λ_d	Dominant Wavelength		626			585			570		nm	[2]
τ_s	Speed of Response		200			200			200		ns	
C	Capacitance[5]		35	100		35	100		35	100	pF	V_1=0; f=1 MHz
Θ_{JC}	Thermal Resistance*		425			425			425		°C/W	[3]
Θ_{JC}	Thermal Resistance**		550			550			550		°C/W	[3]
V_F	Forward Voltage		2.0	3.0		2.0	3.0		2.1	3.0	V	I_F = 20mA Figures 2,7,12
									At I_F = 25mA			
I_R	Reverse Current			1.0			1.0			1.0	μA	V_R = 3V
BV_R	Reverse Breakdown Voltage	5.0			5.0			5.0			V	I_R = 100μA
η_V	Luminous Efficacy		140			455			600		lm/W	[4]

NOTES:
1. $\Theta_{1/2}$ is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
2. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.
3. Junction to Cathode Lead with 3.18mm (0.125 inch) of leads exposed between base of flange and heat sink.
4. Radiant intensity, I_e, in watts/steradian, may be found from the equation $I_e = I_v/\eta_v$, where I_v is the luminous intensity in candelas and η_v is the luminous efficacy in lumens/watt.
5. Limits do not apply to non screened parts.

*Panel mount. **TO-18.

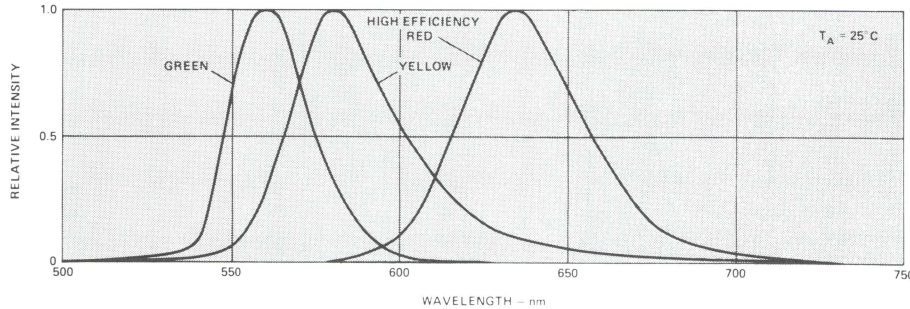
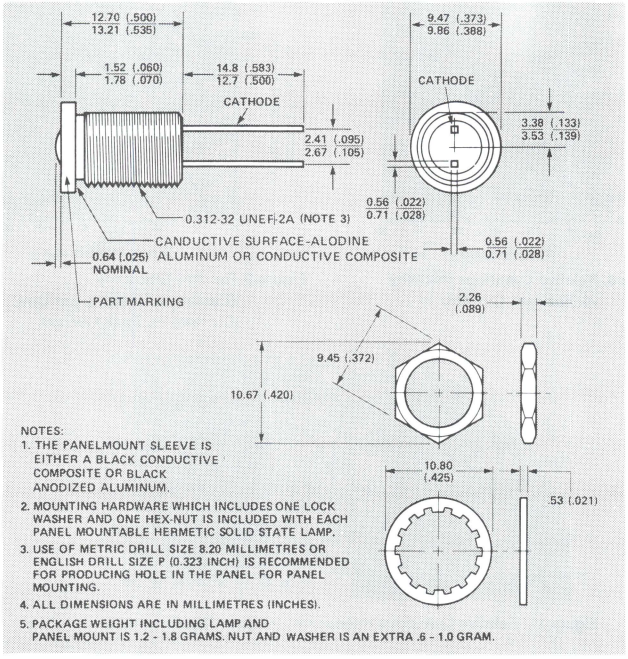


Figure 1. Relative Intensity vs. Wavelength.

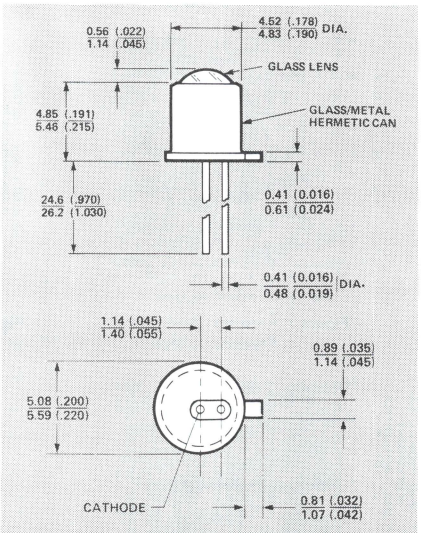
Package Dimensions

HLMP-0364, 0464, 0564



NOTES:
1. THE PANELMOUNT SLEEVE IS EITHER A BLACK CONDUCTIVE COMPOSITE OR BLACK ANODIZED ALUMINUM.
2. MOUNTING HARDWARE WHICH INCLUDES ONE LOCK WASHER AND ONE HEX-NUT IS INCLUDED WITH EACH PANEL MOUNTABLE HERMETIC SOLID STATE LAMP.
3. USE OF METRIC DRILL SIZE 8.20 MILLIMETRES OR ENGLISH DRILL SIZE P (0.323 INCH) IS RECOMMENDED FOR PRODUCING HOLE IN THE PANEL FOR PANEL MOUNTING.
4. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
5. PACKAGE WEIGHT INCLUDING LAMP AND PANEL MOUNT IS 1.2 - 1.8 GRAMS. NUT AND WASHER IS AN EXTRA .6 - 1.0 GRAM.

HLMP-0363, 0463, 0563



OUTLINE TO-18

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES (INCHES).
2. GOLD-PLATED LEADS.
3. PACKAGE WEIGHT OF LAMP ALONE IS .25 - .40 GRAMS.

Family of High Efficiency Red HLMP-0363/HLMP-0364

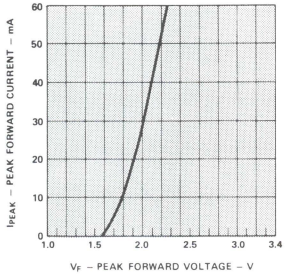


Figure 2. Forward Current vs. Forward Voltage.

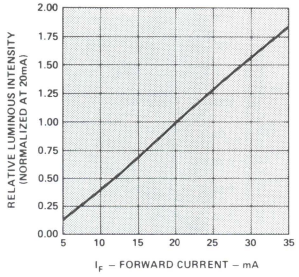


Figure 3. Relative Luminous Intensity vs. Forward Current.

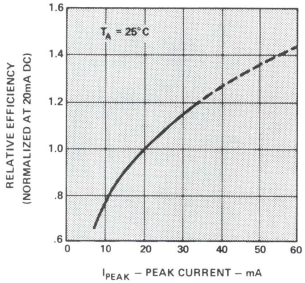


Figure 4. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

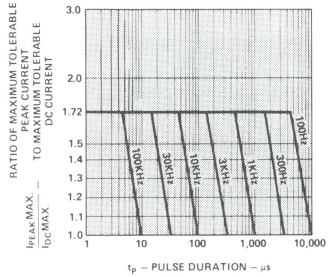


Figure 5. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

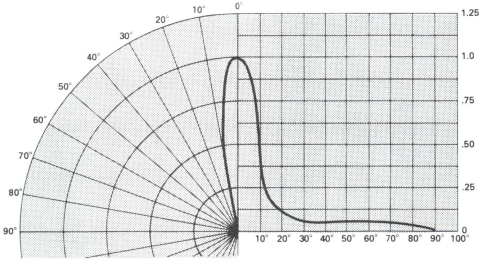


Figure 6. Relative Luminous Intensity vs. Angular Displacement.

Family of Yellow HLMP-0463/HLMP-0464

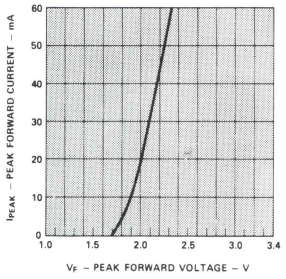


Figure 7. Forward Current vs. Forward Voltage.

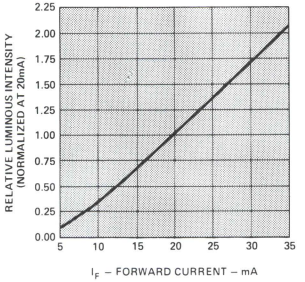


Figure 8. Relative Luminous Intensity vs. Forward Current.

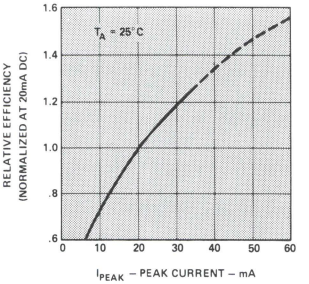


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

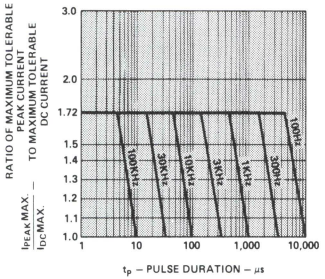


Figure 10. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

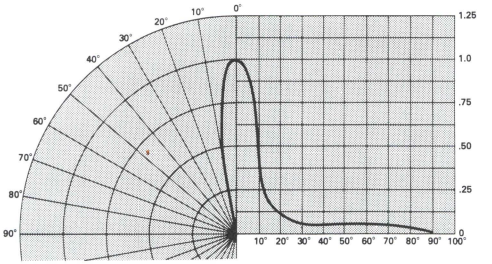


Figure 11. Relative Luminous Intensity vs. Angular Displacement.

Family of Green HLMP-0563/HLMP-0564

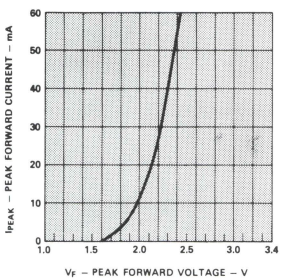


Figure 12. Forward Current vs. Forward Voltage.

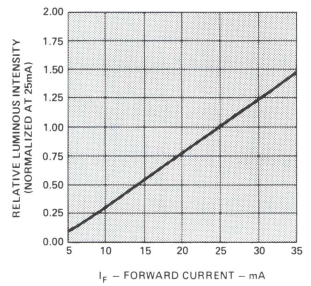


Figure 13. Relative Luminous Intensity vs. Forward Current.

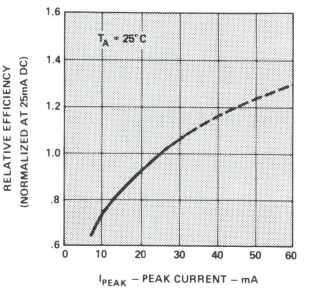


Figure 14. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current.

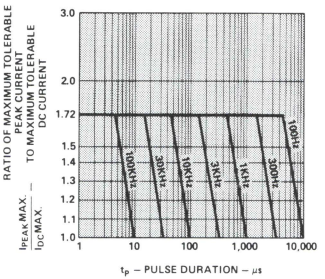


Figure 15. Maximum Tolerable Peak Current vs. Pulse Duration. (I_{DC} MAX as per MAX Ratings)

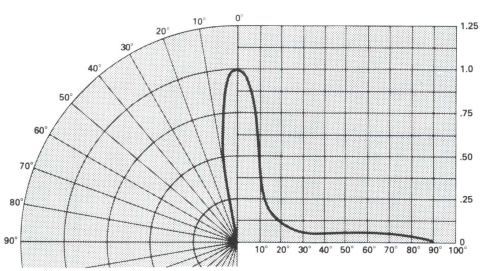


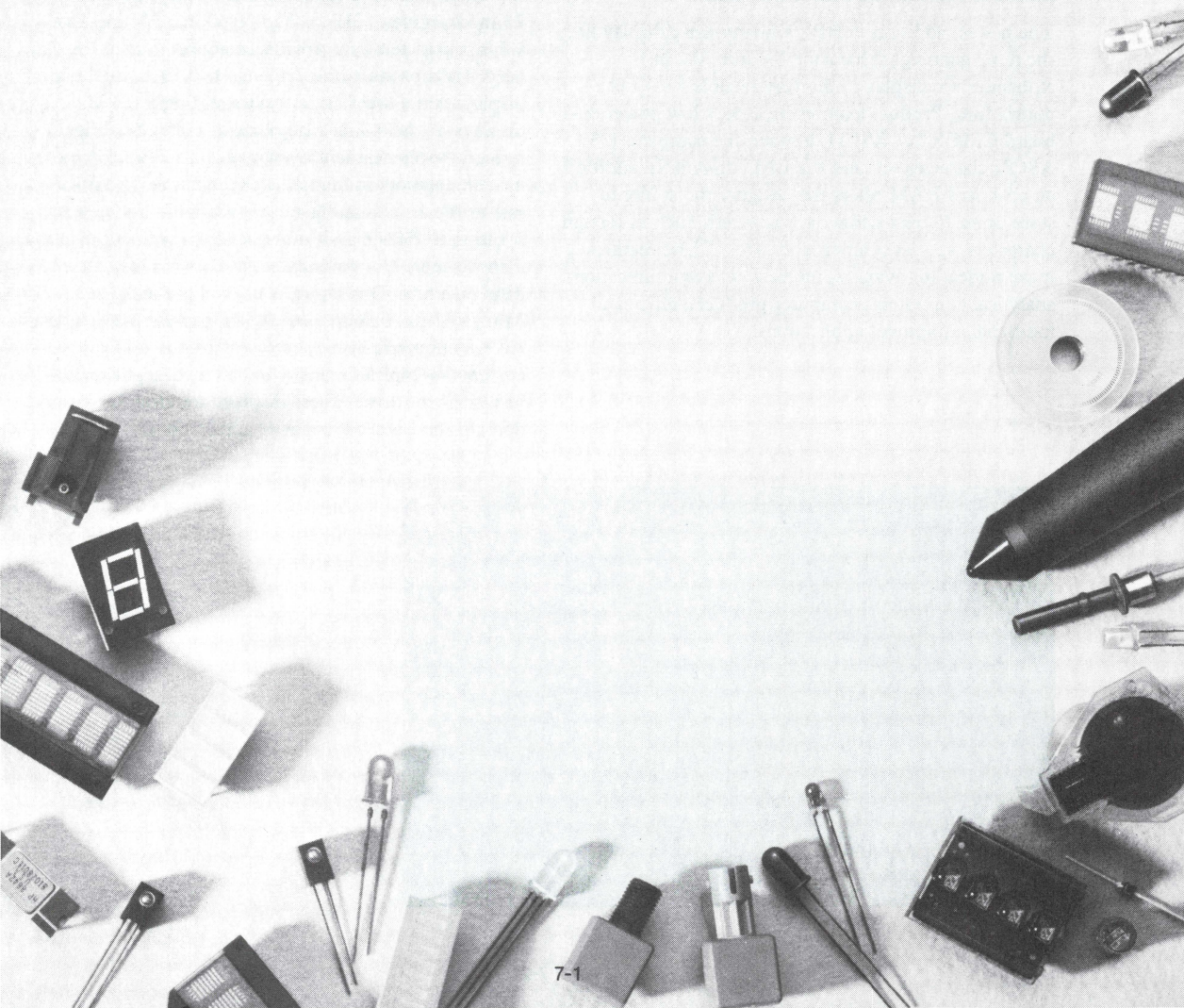
Figure 16. Relative Luminous Intensity vs. Angular Displacement.

Contrast Enhancement

The objective of contrast enhancement is to optimize display readability. Adequate contrast enhancement can be achieved in indoor applications through luminous contrast techniques. Luminous contrast is the observed brightness of the illuminated indicator compared to the brightness of the surround. Appropriate wavelength filters maximize luminous contrast by reducing the amount of light reflected from the area around the indicator while transmitting most of the light emitted by the indicator. These filters are described further in Application Note 1015.

Solid State Displays

- Smart Alphanumeric Displays
- Alphanumeric Displays
- AlGaAs Seven Segment Displays
- Seven Segment Displays
- Hexadecimal and Dot Matrix Displays
- Hermetic Displays



Solid State Displays

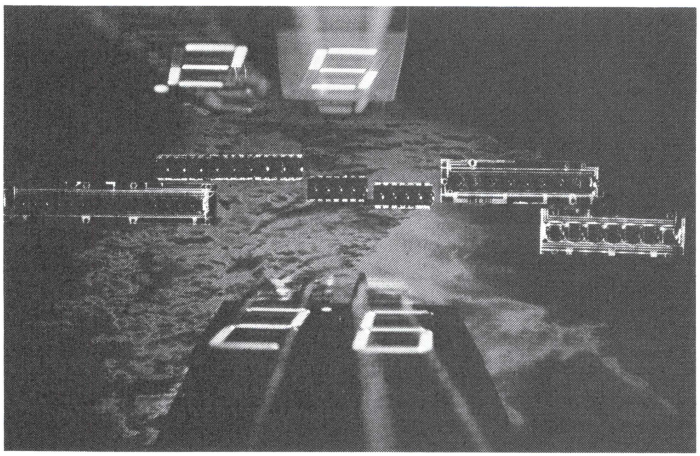
Hewlett-Packard's line of Solid State Displays answers all the needs of the designer. From smart alphanumeric displays to low cost numeric displays in sizes from 3 mm (0.15 in.) to 20 mm (0.8 in.) and colors of red, high efficiency red, yellow, and high performance green, the selection is complete.

Hewlett-Packard's 5 x 7 dot matrix alphanumeric display line comes in 3 character sizes: 3.8 mm (0.15 in.), 5 mm (0.2 in.), and 6.9 mm (0.27 in.). In addition, there are now 4 colors available for each size: standard red, yellow, high efficiency red, and green. This wide selection of package sizes and colors makes these products ideal for a variety of applications in avionics, industrial control, and instrumentation.

The newest addition to HP's alphanumeric display line, the intelligent eight character, 5.0 mm (0.2 in.) alphanumeric display in the very flexible 5 x 7 dot matrix font. Product features include, a low power on-board CMOS IC, ASCII decoder, the complete 128 ASCII character set, and the LED drivers. In addition, an on-board RAM offers the designer the ability to store up to 16 user-definable characters, such as foreign characters, special symbols and logos. These features make it ideal for avionics, medical, telecommunications, analytical equipment, computer products, office and industrial equipment applications.

Another addition to HP's alphanumeric display line is the large (0.68 inch and 1.04 inch) 5 x 7 dot matrix alphanumeric display family. This family is offered in standard red (both sizes), high efficiency red (1.04 inch only) and high performance green (both sizes). These displays have excellent viewability; the 1.04 inch character font can be read at up to 18 meters (12 meters for the 0.68 inch display). Applicationis for these large 5 x 7 displays include industrial machinery and process controllers, weighing scales, computer tape drive systems and transportation.

Hewlett-Packard's line of numeric seven segment displays is one of the broadest. From low cost, standard red displays to high light ambient displays producing 7.5 mcd/segment, HP's 0.3 in., 0.43 in., 0.56 in., and 0.8 in. characters can provide a solution to every display need. HP's product offering include 0.56 in. dual digit displays and a line fo small package, bright 0.3 in. displays — the 0.3 in. Microbright. HP's borad line of numeric seven segment displays are ideal for electronic instrumentation, industrial, weighing scales, point-of-sale terminals and appliance applications. The newest addition to HP's line of numeric seven segment displays is the Double Heterojunction AlGaAs red low current display family. This family is offered in the 0.3 min. Mini, 0.43 in., 0.56 in., and 0.8 in. package sizes. These AlGaAs numeric displays are very bright at low drive currents — typical intensity of 650 mcd/segment at 1 mA/segment drive. These displays are ideal for battery operated and other low power applications.



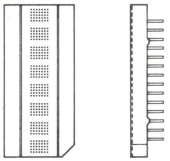
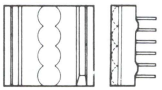
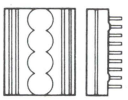
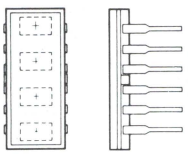
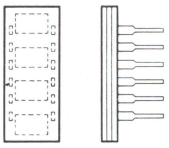
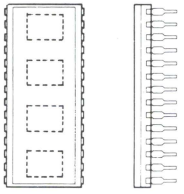
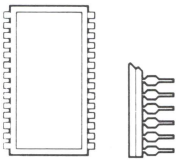
High Reliability Displays

In addition to Hewlett-Packard commercial solid state displays, Hewlett-Packard offers a complete line of hermetic packages for high reliability military and aerospace applications. These package consists of numeric and hexadecimal displays, 5 x 7 dot matrix alphanumeric displays with extended temperature ranges, and fully intelligent monolithic 16 segment displays with extended temperature ranges and on board CMOS IC's. Similar to the commercial display product selection, the high reliability display products are available in a variety of character sizes and all four colors: standard red, high efficiency red, yellow, and high performance green.

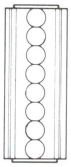
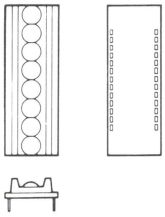
Hewlett-Packard offers three different testing programs for the high reliability conscious display customer. These programs include DESC Qualification on the MIL-D-87157 for the hermetically sealed 4N51-4N54 hexadecimal and numeric displays; and two levels of in-house high reliability testing programs that conform or a modification to MIL-D-87157 Quality Level A Test Tables for all other high reliability display products. Please refer to the individual data sheets for a complete description of each display's testing program.

Integrated numeric and hexadecimal displays (with on-board IC's) solve the designer's decoding/driving problems. They are available in plastic packages for general purpose usage, ceramic/glass packages for industrial applications, and hermetic packages for high reliability applications. This family of displays has been designed for ease of use in a wide range of environments.

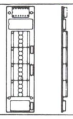
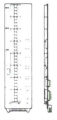
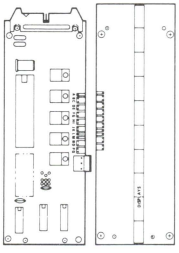
Alphanumeric LED Displays

Device	P/N	Description	Color	Application	Page No.
	HDSP-2111 HDSP-2112	5.0 mm (0.2 in.) 5 x 7 Eight Character Intelligent Display Operating Temperature Range: -20°C to +70°C	Yellow High Efficiency Red	• Avionics • Medical • Telecommunications • Analytical Equipment • Computer Products • Office Equipment • Industrial Equipment	7-19
	HPDL-1414	2.85 mm (.112") Four Character Monolithic Smart Alphanumeric Display Operating Temperature Range: -40°C to +85°C	Red	• Portable Data Entry Devices • Industrial Instrumentation • Computer Peripherals • Telecommunication Equipment	7-30
	HPDL-2416	4.1 mm (.16") Four Character Monolithic Smart Alphanumeric Display Operating Temperature Range: -40°C to +85°C	Red	• Portable Data Entry Devices • Medical Equipment • Industrial Instrumentation • Computer Peripherals • Telecommunication Equipment	7-38
	HDSP-2000 HDSP-2001 HDSP-2002 HDSP-2003	3.8 mm (.15") 5 x 7 Four Character Alphanumeric 12 Pin Ceramic 7.62 mm (.3") DIP with untinted glass lens. Operating Temperature Range: -20°C to +85°C	Red Yellow High Efficiency Red High Performance Green	• Computer Terminals • Business Machines • Portable, Hand-held or mobile data entry, read-out or communications For further information see Application Note 1016.	7-46
	HDSP-2300 HDSP-2301 HDSP-2302 HDSP-2303	5.0 mm (.20") 5 x 7 Character Alphanumeric 12 Pin Ceramic 6.35 mm (.25") DIP with untinted glass lens Operating Temperature Range: -20°C to +85°C	Red Yellow High Efficiency Red High Performance Green	• Avionics • Grounds Support, Cockpit, Shipboard Systems • Medical Equipment • Industrial and Process control • Computer Peripherals and Terminals For further information see Application Note 1016.	7-50
	HDSP-2490 HDSP-2491 HDSP-2492 HDSP-2493	6.9 mm (.27") 5 x 7 Four Character Alphanumeric 28 Pin Ceramic 15.24 mm (.6") DIP with untinted glass lens Operating Temperature Range: -20°C to +85°C	Red Yellow High Efficiency Red High Performance Green	• High Brightness Ambient Systems • Industrial and Process Control • Computer Peripherals • Ground Support Systems For further information see Application Note 1016.	7-56
	5082-7100 5082-7101 5082-7102	6.9 mm (.27") 5 x 7 Three Character Alphanumeric 22 Pin Ceramic 15.2 mm (.6") DIP 6.9 mm (.27") 5 x 7 Four Character Alphanumeric 28 Pin Ceramic 15.2 mm (.6") DIP 6.9 mm (.27") 5 x 7 Five Character Alphnumeric 36 Pin Ceramic 15.2 mm (.6") DIP	Red Untinted Glass Lens	General Purpose Market • Business Machines • Calculators • Solid State CRT • Industrial Equipment	7-80

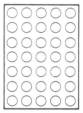
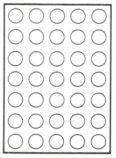
Alphanumeric LED Displays (cont.)

Device		Description	Color	Application	Page No.
	HDSP-6504	3.8 mm (.15") Sixteen Segment Four Character Alphanumeric 22 Pin 15.2 mm (.6") DIP	Red	• Computer Terminals • Hand Held Instruments • In-Plant Control Equipment • Diagnostic Equipment	7-84
	HDSP-6508	3.8 mm (.15") Sixteen Segment Eight Character Alphanumeric 26 Pin 15.2 mm (.6") DIP			
	HDSP-6300	3.56 mm (.14") Sixteen Segment Eight Character Alphanumeric 26 Pin 15.2 mm (.6") DIP		• Computer Peripherals and Terminals • Computer Base Emergency Mobile Units • Automotive Instrument Panels • Desk Top Calculators • Hand-Held Instruments For further information ask for Application Note 931.	7-90

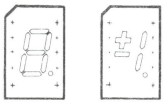
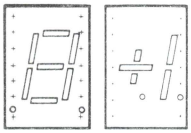
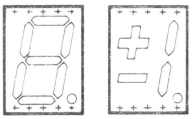
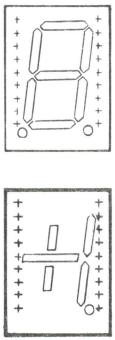
Alphanumeric Display Systems

Device	P/N	Description	Color	Application	Page No.
	HDSP-6621	Single Line 16 Character Display Board Utilizing the HPDL-1414	114.30 mm (4.50") L x 30.48 mm (1.20") H x 8.12 mm (0.32") D	• Computer Peripherals • Telecommunications • Industrial Equipment • Instruments	7-60
	HDSP-6624	Single Line 32 Character Display Board Utilizing the HPDL-2416	223.52 mm (8.80") L x 58.42 mm (2.30") H x 15.92 mm (0.62") D		
	HDSP-2416	Single-Line 16 Character Display Panel Utilizing the HDSP-2000	162.56 mm (6.4") L x 58.42 mm (2.3") H x 7.11 mm (0.28") D	• Data Entry Terminals • Instrumentation	7-68
	HDSP-2424	Single-Line 24 Character Display Panel Utilizing the HDSP-2000			
	HDSP-2432	Single-Line 32 Character Display Panel Utilizing the HDSP-2000			
	HDSP-2440	Single-Line 40 Character Display Panel Utilizing the HDSP-2000 Display	177.80 mm (7.0") L x 58.42 mm (2.3") H x 7.11 mm (.28") D		
	HDSP-2470	HDSP-2000 Display Interface Incorporating a 64 Character ASCII Decoder	171.22 mm (6.74") L x 58.42 mm (2.3") H x 16.51 mm (.65") D		
	HDSP-2471	HDSP-2000 Display Interface Incorporating a 128 Character ASCII Decoder			
	HDSP-2472	HDSP-2000 Display Interface without ASCII Decoder. Instead, a 24 Pin Socket is Provided to Accept a Custom 128 Character Set from a User Programmed 1K x 8 PROM			

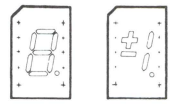
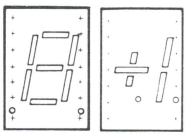
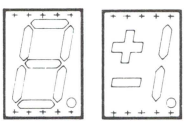
Large Alphanumeric Displays

Device	P/N	Description	Package	Typical I_V @ 50 mA Peak, 1/5 Duty Factor	Page No.
	HDSP-4701	Red, Common Row Anode	17.3 mm (0.68") Dual-in-Line 0.70" H x 0.50"W x 0.26" D	770 μcd/dot (100 mA Peak, 1/5 Duty Factor)	7-95
	HDSP-4703	Red, Common Row Cathode			
	HDSP-4401	Red, Common Row Anode	26.5 mm (1.04") Dual-in-Line 1.10" H x 0.79"W x 0.25" D	860 μcd/dot (100 mA Peak, 1/5 Duty Factor)	
	HDSP-4403	Red, Common Row Cathode			
	HDSP-4501	High Efficiency Red, Common Row Anode		3500 μcd/dot	
	HDSP-4503	High Efficiency Red, Common Row Cathode			

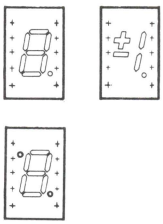
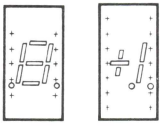
Double Heterojunction AlGaAs Red Low Current Seven Segment LED Displays

Package	Device	Description	Typical I_V @ 1 mA DC	Page No.
 7.62 mm (0.3") Mini Dual-in-Line 0.5"H x 0.3"W x 0.24"D	HDSP-A101 HDSP-A103 HDSP-A107 HDSP-A108	AlGaAs Red, Common Anode, RHDP AlGaAs Red, Common Cathode, RHDP AlGaAs Red, Overflow ±1 Common Anode AlGaAs Red, Overflow ±1 Common Cathode	600 μcd/seg.	7-103
 10.92 mm (0.43") Dual-in-line 0.75"H x 0.5"W x 0.25"D	HDSP-E100 HDSP-E101 HDSP-E103 HDSP-E106	AlGaAs Red, Common Anode, LHDP AlGaAs Red, Common Anode, RHDP AlGaAs Red, Common Cathode, RHDP AlGaAs Red, Universal Overflow ±1	650 μcd/seg.	
 14.2 mm (0.56") Dual-in-Line (Single Digit) 0.67"H x 0.49"W x 0.31"D	HDSP-H101 HDSP-H103 HDSP-H107 HDSP-H108	AlGaAs Red, Common Anode, RHDP AlGaAs Red, Common Cathode, RHDP AlGaAs Red, Overflow ±1 Common Anode AlGaAs Red, Overflow ±1 Common Cathode	700 μcd/seg.	
 20 mm (0.8") Dual-in-Line 1.09"H x 0.78"W x 0.33"D	HDSP-N100 HDSP-N101 HDSP-N103 HDSP-N105 HDSP-N106	AlGaAs Red, Common Anode, LHDP AlGaAs Red, Common Anode, RHDP AlGaAs Red, Common Cathode, RHDP AlGaAs Red, Common Cathode, LHDP AlGaAs Red, Universal Overflow ±1	590 μcd/seg.	

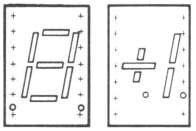
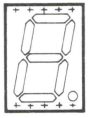
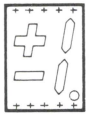
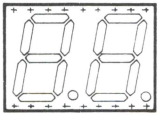
High Efficiency Red Low Current Seven Segment LED Displays

Package	Device	Description	Typical I_V @ 2 mA DC	Page No.
 7.62 mm (0.3") Microbright Dual-in-Line 0.5"H x 0.3"W x 0.24"D	HDSP-7511 HDSP-7513 HDSP-7517 HDSP-7518	High Efficiency Red, Common Anode, RHDP High Efficiency Red, Common Cathode, RHDP High Efficiency Red, Overflow ±1 Common Anode High Efficiency Red, Overflow ±1 Common Cathode	270 μcd/seg.	7-109
 10.92 mm (0.43") Dual-in-line 0.75"H x 0.5"W x 0.25"D	HDSP-3350 HDSP-3351 HDSP-3353 HDSP-3356	High Efficiency Red, Common Anode, LHDP High Efficiency Red, Common Anode, RHDP High Efficiency Red, Common Cathode, RHDP High Efficiency Red, Universal Polarity and Overflow Indicator, RHDP	300 μcd/seg.	
 14.2 mm (0.56") Dual-in-Line (Single Digit) 0.67"H x 0.49"W x 0.31"D	HDSP-5551 HDSP-5553 HDSP-5557 HDSP-5558	High Efficiency Red, Common Anode, RHDP High Efficiency Red, Common Cathode, RHDP High Efficiency Red, Overflow ±1 Common Anode High Efficiency Red, Overflow ±1 Common Cathode	370 μcd/seg.	

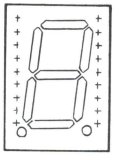
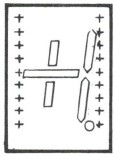
Red, High Efficiency Red, Yellow, and High Performance Green Seven Segment LED Displays

Package	Device	Description	Typical I_V @ 20 mA DC	Page No.
 7.62 mm (.3") Microbright Dual-in-Line .5" H x .3" W x .24" D	HDSP-7301	Red, Common Anode, RHDP	1100 μcd/seg	7-115
	HDSP-7302	Red, Common Anode, RHDP, Colon		
	HDSP-7303	Red, Common Cathode, RHDP		
	HDSP-7304	Red, Common Cathode, RHDP, Colon		
	HDSP-7307	Red, Overflow, ±1, Common Anode, RHDP		
	HDSP-7308	Red, Overflow, ±1, Common Cathode, RHDP		
	HDSP-7311	Bright Red, Common Anode, RHDP	1355 μcd/seg	
	HDSP-7313	Bright Red, Common Cathode, RHDP		
	HDSP-7317	Bright Red, Overflow, ±1, Common Anode		
	HDSP-7318	Bright Red, Overflow, ±1, Common Cathode		
	HDSP-7401	Yellow, Common Anode, RHDP	2750 μcd/seg	
	HDSP-7402	Yellow, Common Anode, RHDP, Colon		
	HDSP-7403	Yellow, Common Cathode, RHDP		
	HDSP-7404	Yellow, Common Cathode, RHDP, Colon		
	HDSP-7407	Yellow, Overflow, ±1, Common Anode		
	HDSP-7408	Yellow, Overflow, ±1, Common Cathode		
	HDSP-7501	High Efficiency Red, Common Anode, RHDP	5400 μcd/seg	
	HDSP-7502	High Efficiency Red, Common Anode, RHDP, Colon		
	HDSP-7503	High Efficiency Red, Common Cathode, RHDP		
	HDSP-7504	High Efficiency Red, Common Cathode, RHDP, Colon		
	HDSP-7507	High Efficiency Red, Overflow, ±1, Common Anode		
	HDSP-7508	High Efficiency Red, Overflow, ±1, Common Cathode		
	HDSP-7801	High Performance Green, Common Anode, RHDP	3700 μcd/seg	
	HDSP-7802	High Performance Green, Common Anode, RHDP, Colon		
	HDSP-7803	High Performance Green, Common Cathode, RHDP		
	HDSP-7804	High Performance Green, Common Cathode, RHDP, Colon		
	HDSP-7807	High Performance Green, Overflow, ±1, Common Anode		
	HDSP-7808	High Performance Green, Overflow, ±1, Common Cathode		
 7.62 mm (.3") Dual-in-line .75" H x .4" W x .18" D	5082-7730	Red, Common Anode, LHDP	770 μcd/seg	7-121
	5082-7731	Red, Common Anode, RHDP		
	5082-7736	Red, Universal Polarity and Overflow Indicator, RHDP		
	5082-7740	Red, Common Cathode, RHDP		
	5082-7610	High Efficiency Red, Common Anode, LHDP	4400 μcd/seg	
	5082-7611	High Efficiency Red, Common Anode, RHDP		
	5082-7613	High Efficiency Red, Common Cathode, RHDP		
	5082-7616	High Efficiency Red, Universal Polarity Overflow Indicator, RHDP		
	5082-7620	Yellow, Common Anode, LHDP	3400 μcd/seg	
	5082-7621	Yellow, Common Anode, RHDP		
	5082-7623	Yellow, Common Cathode, RHDP		
	5082-7626	Yellow, Universal Polarity and Overflow Indicator, RHDP		
	HDSP-3600	High Performance Green, Common Anode, LHDP	3950 μcd/seg	
	HDSP-3601	High Performance Green, Common Anode, RHDP		
	HDSP-3603	High Performance Green, Common Cathode, RHDP		
	HDSP-3606	High Performance Green, Universal Overflow Indicator, RHDP		

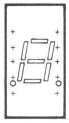
Red, High Efficiency Red, Yellow, and High Performance Green Seven Segment LED Displays (continued)

Package	Device	Description	Typical I_V @ 20 mA DC	Page No.
 10.92 mm (.43") Dual-in-line .75" H x .5" W x .25" D	5082-7750	Red, Common Anode, LHDP	1100 μcd/seg	7-121
	5082-7751	Red, Common Anode, RHDP		
	5082-7756	Red, Universal Polarity and Overflow Indicator, RHDP		
	5082-7760	Red, Common Cathode, RHDP		
	5082-7650	High Efficiency Red, Common Anode, LHDP	6100 μcd/seg	
	5082-7651	High Efficiency Red, Common Anode, RHDP		
	5082-7653	High Efficiency Red, Common Cathode, RHDP		
	5082-7656	High Efficiency Red, Universal Polarity and Overflow Indicator, RHDP		
	5082-7660	Yellow, Common Anode, LHDP	4600 μcd/seg	
	5082-7661	Yellow, Common Anode, RHDP		
	5082-7663	Yellow, Common Cathode, RHDP		
	5082-7666	Yellow, Universal Polarity and Overflow Indicator, RHDP		
	HDSP-4600	High Performance Green, Common Anode, LHDP	3850 μcd/seg	
	HDSP-4601	High Performance Green, Common Anode, RHDP		
	HDSP-4603	High Performance Green, Common Cathode, RHDP		
	HDSP-4606	High Performance Green, Universal Overflow Indicator, RHDP		
  14.2 mm (.56") Dual-in-Line (Single Digit) .67" H x .49" W x .31" D	HDSP-5301	Red, Common Anode, RHDP	1300 μcd/seg	7-130
	HDSP-5303	Red, Common Cathode, RHDP		
	HDSP-5307	Red ±1, Common Anode, RHDP		
	HDSP-5308	Red ±1, Common Cathode, RHDP		
	HDSP-5321	Red, Common Anode, Dual Digit, RHDP		
	HDSP-5323	Red, Common Cathode, Dual Digit, RHDP		
	HDSP-5501	High Efficiency Red, Common Anode, RHDP	6300 μcd/seg	
	HDSP-5503	High Efficiency Red, Common Cathode, RHDP		
	HDSP-5507	High Efficiency Red ±1, Common Anode, RHDP		
	HDSP-5508	High Efficiency Red ±1, Common Cathode, RHDP		
	HDSP-5521	High Efficiency Red, Common Anode, Dual Digit, RHDP		
	HDSP-5523	High Efficiency Red, Common Cathode, Dual Digit, RHDP		
	HDSP-5601	High Performance Green, Common Anode, RHDP	5600 μcd/seg	
	HDSP-5603	High Performance Green, Common Cathode, RHDP		
	HDSP-5607	High Performance Green, Common Anode Overflow Indicator, RHDP		
	HDSP-5608	High Performance Green, Common Cathode Overflow Indicator, RHDP		
 14.2 mm (.56") Dual-in-Line (Dual Digit) .67" H x 1.0" W x .31" D	HDSP-5621	High Performance Green, Common Anode, Dual Digit, RHDP		
	HDSP-5623	High Performance Green, Common Cathode, Dual Digit, RHDP		
	HDSP-5701	Yellow, Common Anode, RHDP	4200 μcd/seg	
	HDSP-5703	Yellow, Common Cathode, RHDP		
	HDSP-5707	Yellow ±1, Common Anode, RHDP		
	HDSP-5708	Yellow ±1, Common Cathode, RHDP		
	HDSP-5721	Yellow, Common Anode, Dual Digit, RHDP		
	HDSP-5723	Yellow, Common Cathode, Dual Digit, RHDP		

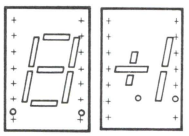
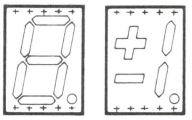
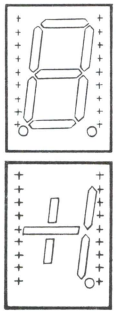
Red, High Efficiency Red, Yellow, and High Performance Green Seven Segment LED Displays (continued)

Package	Device	Description	Typical I_V @ 20 mA DC	Page No.
  20 mm (.8") Dual-in-Line 1.09" H x .78" W x .33" D	HDSP-3400	Red, Common Anode, LHDP	1200 μcd/seg	7-138
	HDSP-3401	Red, Common Anode, RHDP		
	HDSP-3403	Red, Common Cathode, RHDP		
	HDSP-3405	Red, Common Cathode, LHDP		
	HDSP-3406	Red, Universal Polarity Overflow Indicator, RHDP		
	HDSP-3900	High Efficiency Red, Common Anode, LHDP	4800 μcd/seg	
	HDSP-3901	High Efficiency Red, Common Anode, RHDP		
	HDSP-3903	High Efficiency Red, Common Cathode, RHDP		
	HDSP-3905	High Efficiency Red, Common Cathode, LHDP		
	HDSP-3906	High Efficiency Red, Universal Polarity Overflow Indicator, RHDP		
	HDSP-4200	Yellow, Common Anode, LHDP	3400 μcd/seg	
	HDSP-4201	Yellow, Common Anode, RHDP		
	HDSP-4203	Yellow, Common Cathode, RHDP		
	HDSP-4205	Yellow, Common Cathode, LHDP		
	HDSP-4206	Yellow, Universal Polarity Overflow Indicator, RHDP		
	HDSP-8600	High Performance Green, Common Anode, LHDP	3600 μcd/seg	
	HDSP-8601	High Performance Green, Common Anode, RHDP		
	HDSP-8603	High Performance Green, Common Cathode, RHDP		
	HDSP-8605	High Performance Green, Common Cathode, LHDP		
	HDSP-8606	High Performance Green, Universal Overflow Indicator, RHDP		

High Ambient Light, High Efficiency Red, Yellow, and High Performance Green Seven Segment Displays

Package	Device	Description	Typical I_V @ 100 mA Peak 1/5 Duty Factor	Page No.
 7.62 mm (.3") Dual-in-Line .75" H x .4" W x .18" D	HDSP-3530	High Efficiency Red, Common Anode, LHDP	7100 μcd/seg	7-145
	HDSP-3531	High Efficiency Red, Common Anode, RHDP		
	HDSP-3533	High Efficiency Red, Common Cathode, RHDP		
	HDSP-3536	High Efficiency Red, Universal Polarity Overflow Indicator, RHDP		
	HDSP-4030	Yellow, Common Anode, LHDP	4500μcd/seg	
	HDSP-4031	Yellow, Common Anode, RHDP		
	HDSP-4033	Yellow, Common Cathode, RHDP		
	HDSP-4036	Yellow, Universal Polarity Overflow Indicator, RHDP		
	HDSP-3600	High Performance Green, Common Anode, LHDP	7000 μcd/seg (90 mA Peak 1/3 Duty Factor)	7-121
	HDSP-3601	High Performance Green, Common Anode, RHDP		
	HDSP-3603	High Performance Green, Common Cathode, RHDP		
	HDSP-3606	High Performance Green, Universal Overflow Indicator, RHDP		

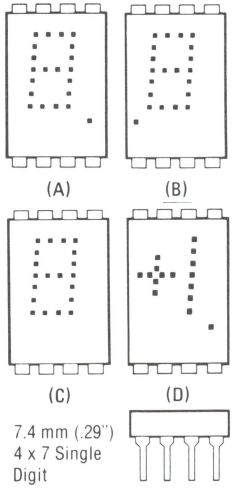
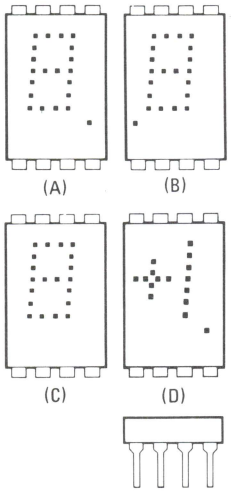
High Ambient Light, High Efficiency Red, Yellow, and High Performance Green Seven Segment Displays (continued)

Package	Device	Description	Typical I_V @ 100 mA Peak 1/5 Duty Factor	Page No.
 10.92 mm (.43") Dual-in-Line .75" H x .5" W x .25" D	HDSP-3730	High Efficiency Red, Common Anode, LHDP	10900 μcd/seg	7-145
	HDSP-3731	High Efficiency Red, Common Anode, RHDP		
	HDSP-3733	High Efficiency Red, Common Cathode, RHDP		
	HDSP-3736	High Efficiency Red, Universal Polarity Overflow Indicator, RHDP		
	HDSP-4130	Yellow, Common Anode, LHDP	5000 μcd/seg	
	HDSP-4131	Yellow, Common Anode, RHDP		
	HDSP-4133	Yellow, Common Cathode, RHDP		
	HDSP-4136	Yellow, Universal Polarity Overflow Indicator, RHDP		
	HDSP-4600	High Performance Green, Common Anode, LHDP	6800μcd/seg	7-121
	HDSP-4601	High Performance Green, Common Anode, RHDP	(90 mA Peak	
	HDSP-4603	High Performance Green, Common Cathode, RHDP	1/3 Duty Factor)	
	HDSP-4606	High Performance Green, Universal Overflow Indicator, RHDP		
 14.2 mm (.56") Dual-in-Line .67" H x .49" W x .31" D	HDSP-5531	High Efficiency Red, Common Anode, RHDP	6000 μcd/seg	7-145
	HDSP-5533	High Efficiency Red, Common Cathode, RHDP		
	HDSP-5537	High Efficiency Red ±1, Common Anode		
	HDSP-5538	High Efficiency Red ±1, Common Cathode		
	HDSP-5731	Yellow, Common Anode, RHDP	5500 μcd/seg	
	HDSP-5733	Yellow, Common Cathode, RHDP		
	HDSP-5737	Yellow, ±1, Common Anode		
	HDSP-5738	Yellow, ±1, Common Cathode		
	HDSP-5601	High Performance Green, Common Anode, RHDP	9400 μcd/seg	7-130
	HDSP-5603	High Performance Green, Common Cathode, RHDP	(90 mA Peak	
	HDSP-5607	High Performance Green, Common Anode Overflow Indicator	1/3 Duty Factor)	
	HDSP-5608	High Performance Green, Common Cathode Overflow Indicator		
 20 mm (.8") Dual-in-Line 1.09" H x .78" W x .33" D	HDSP-3900	High Efficiency Red, Common Anode, LHDP	7000 μcd/seg	7-145
	HDSP-3901	High Efficiency Red, Common Anode, RHDP		
	HDSP-3903	High Efficiency Red, Common Cathode, RHDP		
	HDSP-3905	High Efficiency Red, Common Cathode, LHDP		
	HDSP-3906	High Efficiency Red, Universal Overflow Indicator, RHDP		
	HDSP-4200	Yellow, Common Anode, LHDP	7000 μcd/seg	
	HDSP-4201	Yellow, Common Anode, RHDP		
	HDSP-4203	Yellow, Common Cathode, RHDP		
	HDSP-4205	Yellow, Common Cathode, LHDP		
	HDSP-4206	Yellow, Universal Polarity Overflow Indicator, RHDP		
	HDSP-8600	High Performance Green, Common Anode, LHDP	5800 μcd/seg	
	HDSP-8601	High Performance Green, Common Anode, RHDP	(90 mA Peak	
	HDSP-8603	High Performance Green, Common Cathode, RHDP	1/3 Duty Factor)	
	HDSP-8605	High Performance Green, Common Cathode, LHDP		
	HDSP-8606	High Performance Green, Universal Overflow Indicator, RHDP		

Solid State Display Intensity and Color Selections

Option	Description	Page No.
Option S01 Option S02 Option S20	Intensity and Color Selected Displays	7-153

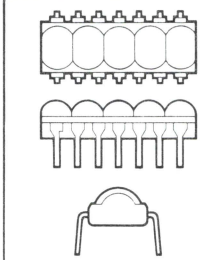
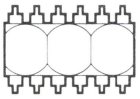
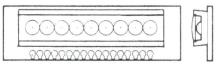
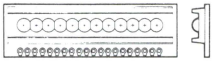
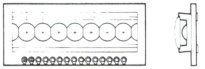
Hexadecimal and Dot Matrix Displays

Device		Description	Package	Application	Page No.
 (A) (B) (C) (D) 7.4 mm (.29") 4 x 7 Single Digit	5082-7300 (A)	Numeric RHDP Built-in Decoder/Driver/Memory	8 Pin Epoxy 15.2 mm (.6") DIP	General Purpose Market • Test Equipment • Business Machines • Computer Peripherals • Avionics	7-154
	5082-7302 (B)	Numeric LHDP Built-in Decoder/Driver/Memory			
	5082-7340 (C)	Hexadecimal Built-in Decoder/Driver/Memory			
	5082-7304 (D)	Over Range ±1			
	5082-7356 (A)	Numeric RHDP Built-in Decoder/Driver/Memory	8 Pin Glass Ceramic 15.2 mm (.6") DIP	• Medical Equipment • Industrial and Process Control Equipment • Computers • Where Ceramic Package IC's are required • High Reliability Applications	7-158
	5082-7357 (B)	Numeric LHDP Built-in Decoder/Driver/Memory			
	5082-7359 (C)	Hexadecimal Built-in Decoder/Driver/Memory			
	5082-7358 (D)	Over Range ±1			
 (A) (B) (C) (D) 7.4 mm (.29") 4 x 7 Single Digit Package: 8 Pin Glass Ceramic 15.2 mm (.6") DIP	HDSP-0760 (A)	Numeric RHDP Built in Decoder/Driver/Memory	High Efficiency Red Low Power	• Military Equipment • Ground Support Equipment • Avionics • High Reliability Applications	7-163
	HDSP-0761 (B)	Numeric LHDP Built in Decoder/Driver/Memory			
	HDSP-0762 (C)	Hexadecimal Built in Decoder/Driver/Memory			
	HDSP-0763 (D)	Over Range ± 1			
	HDSP-0770 (A)	Numeric RHDP Built in Decoder/Driver/Memory	High Efficiency Red High Brightness	• High Brightness Ambient Systems • Cockpit, Shipboard Equipment • High Reliability Applications	
	HDSP-0771 (B)	Numeric LHDP Built in Decoder/Driver/Memory			
	HDSP-0772 (C)	Hexadecimal Built in Decoder/Driver/Memory			
	HDSP-0763 (D)	Over Range ± 1			
	HDSP-0860 (A)	Numeric RHDP Built in Decoder/Driver/Memory	Yellow	• Business Machines • Fire Control Systems • Military Equipment • High Reliability Applications	
	HDSP-0861 (B)	Numeric LHDP Built in Decoder/Driver/Memory			
	HDSP-0862 (C)	Hexadecimal Built in Decoder/Driver/Memory			
	HDSP-0863 (D)	Over Range ± 1			

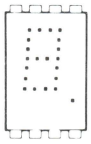
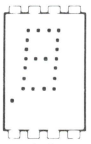
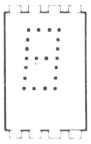
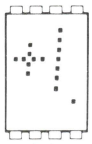
Hexadecimal and Dot Matrix Displays (continued)

Device and Package		Description	Color	Application	Page No.
(See previous page)	HDSP-0960 (A)	Numeric RHDP Built in Decoder/Driver/Memory	High Performance Green	• Business Machines • Fire Control Systems • Military Equipment • High Reliability Applications	7-163
	HDSP-0961 (B)	Numeric LHDP Built in Decoder/Driver/Memory			
	HDSP-0962 (C)	Hexadecimal Built in Decoder/Driver/Memory			
	HDSP-0963 (D)	Over Range ± 1			

Monolithic Numeric Displays

Device		Description	Package	Application	Page No.
	5082-7404	2.79 mm (.11") Red, 4 Digits Centered D.P.	12 Pin Epoxy, 7.62 mm (.3") DIP	Small Display Market • Portable/Battery Power Instruments • Portable Calculators • Digital Counters • Digital Thermometers • Digital Micrometers • Stopwatches • Cameras • Copiers • Digital Telephone Peripherals • Data Entry Terminals • Taxi Meters For further information ask for Application Note 937.	7-169
	5082-7405	2.79 mm (.11") Red, 5 Digits, Centered D.P.	14 Pin Epoxy, 7.62 mm (.3") DIP		
	5082-7414	2.79 mm (.11") Red, 4 Digits, RHDP	12 Pin Epoxy, 7.62 mm (.3") DIP		
	5082-7415	2.79 mm (.11") Red, 5 Digits, RHDP	14 Pin Epoxy, 7.62 mm (.3") DIP		
	5082-7432	2.79 mm (.11") Red, 2 Digits, Right, RHDP	12 Pin Epoxy, 7.62 mm (.3") DIP		
	5082-7433	2.79 mm (.11") Red, 3 Digits, RHDP			
	5082-7441	2.67 mm (.105") Red, 9 Digits, Mounted on P.C. Board	50.8 mm (2") PC Bd., 17 Term. Edge Con.		7-174
	5082-7446	2.92 mm (.115") Red, 16 Digits, Mounted on P.C. Board	69.85 mm (2.750") PC Bd., 24 Term. Edge Con.		
	5082-7295	4.45 mm (.175") Red, 15 Digits, Mounted on P.C. Board. RHDP	91.2 mm (3.59") PC Bd., 23 Term. Edge Con.		

Hermetic Hexadecimal and Numeric Dot Matrix Displays

Device		Description	Package	Application	Page No.
 (A)  (B)  (C)  (D) 7.4 mm (.29") 4 x 7 Single Digit Package 8 Pin Glass Ceramic 15.2mm (.6") DIP Truly Hermetic	4N51 4N51TXV M87157/00101ACX[1] (4N51TXVB) (A)	Numeric RHDP Decoder/Driver/Memory TXV — Hi Rel Screened	8 Pin Hermetic Built-in 15.2 mm (.6") DIP with gold plated leads	• Military High Reliability Applications • Avionics/Space Flight Systems • Fire Control Systems • Ground Support, Shipboard Equipment	7-182
	4N52 4N52TXV M87157/00102ACX[1] (4N52TXVB) (B)	Numeric LHDP Built-in Decoder/Driver/Memory TXV — Hi Rel Screened			
	4N54 4N54TXV M87157/00103ACX[1] (4N54TXVB) (C)	Hexadecimal Built-in Decoder/Driver/Memory TXV — Hi Rel Screened			
	4N53 4N53TXV 104ACX[1] (4N53TXVB) (D)	Character Plus/Minus Sign TXV — Hi Rel Screened			
	HDSP-0781 (A) HDSP-0781 TXV HDSP-0781 TXVB	Numeric RHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Efficiency Red, Low Power	• Ground, Airborne, Shipboard Equipment • Fire Control Systems • Space Flight Systems • Other High Reliability Uses	7-190
	HDSP-0782 (B) HDSP-0782 TXV HDSP-0782 TXVB	Numeric LHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0783 (D) HDSP-0783 TXV HDSP-0783 TXVB	Overrange ±1 TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0784 (C) HDSP-0784 TXV HDSP-0784 TXVB	Hexadecimal, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0791 (A) HDSP-0791 TXV HDSP-0791 TXVB	Numeric RHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Efficiency Red, High Brightness	• Ground, Airborne, Shipboard Equipment • Fire Control Systems • Space Flight Systems • Other High Reliability Uses	
	HDSP-0792 (B) HDSP-0792 TXV HDSP-0792 TXVB	Numeric LHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			

[1] Military Approved and Qualified for High Reliability Applications.

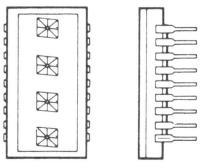
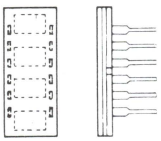
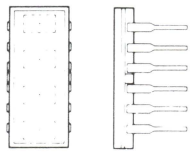
Hermetic Hexadecimal and Numeric Dot Matrix Displays (continued)

Device		Description	Color	Application	Page No.
(See previous page)	HDSP-0783 (D) HDSP-0783 TXV HDSP-0783 TXVB	Overrange ±1 TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Efficiency Red. High Brightness	• Ground, Airborne, Shipboard Equipment • Fire Control Systems • Space Flight Systems • Other High Reliability Uses	7-190
	HDSP-0794 (C) HDSP-0794 TXV HDSP-0794 TXVB	Hexadecimal, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0881 (A) HDSP-0881 TXV HDSP-0881 TXVB	Numeric RHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	Yellow		
	HDSP-0882 (B) HDSP-0882 TXV HDSP-0882 TXVB	Numeric LHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0883 (D) HDSP-0883 TXV HDSP-0883 TXVB	Overrange ±1 TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0884 (C) HDSP-0884 TXV HDSP-0884 TXVB	Hexadecimal, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
(See previous page)	HDSP-0981 (A) HDSP-0981 TXV HDSP-0981 TXVB	Numeric RHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Performance Green		
	HDSP-0982 (B) HDSP-0982 TXV HDSP-0982 TXVB	Numeric LHDP, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			
	HDSP-0983 (C) HDSP-0983 TXV HDSP-0983 TXVB	Overrange ±1 TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157			

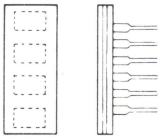
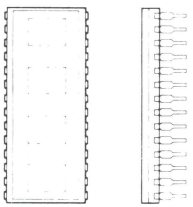
Hermetic Hexadecimal and Numeric Dot Matrix Displays (continued)

Device		Description	Color	Application	Page No.
(See previous page)	HDSP-0984 (D) HDSP-0984 TXV HDSP-0984 TXVB	Hexadecimal, Built-in Decoder/Driver Memory TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	High Performance Green	• Ground, Airborne, Shipboard Equipment • Fire Control Systems • Space Flight Systems • Other High Reliability Uses	7-190

Hermetic Alphanumeric Displays

Device		Description	Color	Application	Page No.
	HMDL-2416 HMDL-2416 TXV HMDL-2416 TXVB	4.1 mm (0.16") Four Character Monolithic Smart Alphanumeric Display Operating Temperature Range: -55°C to 100°C	Red	• Military Equipment • High Reliability Applications • Military Telecommunications	7-204
	HDSP-2351 HDSP-2351 TXV HDSP-2351 TXVB	4.87 mm (0.19") 5 x 7 Four Character Alphanumeric Sunlight Viewable Display Operating Temperature Range: -55°C to 100°C	Yellow	• Military Avionics • Military Cockpit • Military Ground Support Systems	7-214
	HDSP-2352 HDSP-2352 TXV HDSP-2352 TXVB		High Efficiency Red		
	HDSP-2353 HDSP-2353 TXV HDSP-2353 TXVB		High Performance Green		
	HDSP-2010 HDSP-2010 TXV HDSP-2010 TXVB	3.7 mm (.15") 5 x 7 Four Character Alphanumeric Operating Temperature Range: -40°C to +85°C TXV Hi Rel Screened TXVB Hi Rel Screened to Level A MIL-D-87157	Red, Red Glass Contrast Filter	• Extended temperature applications requiring high reliability. • I/O Terminals • Avionics For further information see Application Note 1016.	7-198

Hermetic Alphanumeric Displays (continued)

Device		Description	Color	Application	Page No.
	HDSP-2310 HDSP-2310 TXV HDSP-2310 TXVB	5.0 mm (.20") 5 x 7 Four Character Alphanumeric 12 Pin Ceramic 6.35 mm (.25") DIP with untinted glass lens Operating Temperature Range: -55°C to +85°C True Hermetic Seal TXV — Hi Rel Screened TXVB — Hi Rel Screened to Level A MIL-D-87157	Standard Red	• Military Equipment • Avionics • High Rel Industrial Equipment	7-228
	HDSP-2311 HDSP-2311 TXV HDSP-2311 TXVB		Yellow		
	HDSP-2312 HDSP-2312 TXV HDSP-2312 TXVB		High Eff. Red		
	HDSP-2313 HDSP-2313 TXV HDSP-2313 TXVB		High Performance Green		
	HDSP-2450 HDSP-2450 TXV HDSP-2450 TXVB	Operating Temperature Range: -55°C to +85°C 6.9 mm (.27") 5 x 7 Four Character Alphanumeric 28 Pin Ceramic 15.24 mm (.6") DIP True Hermetic Seal TXV — Hi Rel Screened TXVB — Hi Rel Screened to Level A MIL-D-87157	Red	• Military Equipment • High Reliability Applications • Avionics • Ground Support, Cockpit, Shipboard Systems	7-235
	HDSP-2451 HDSP-2451 TXV HDSP-2451 TXVB		Yellow		
	HDSP-2452 HDSP-2452 TXV HDSP-2452 TXVB		High Efficiency Red		
	HDSP-2453 HDSP-2453 TXV HDSP-2453 TXVB		High Performance Green		

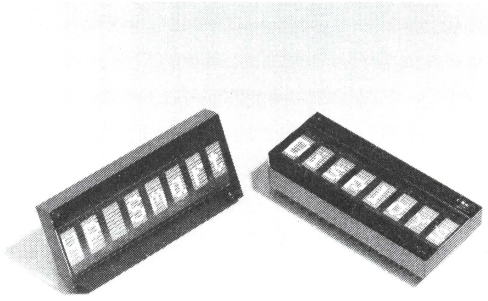
HEWLETT PACKARD

EIGHT CHARACTER 5.0 mm (0.2 INCH) SMART 5 x 7 ALPHANUMERIC DISPLAYS

YELLOW HDSP-2111
HIGH EFFICIENCY RED HDSP-2112

Features

- **SMART ALPHANUMERIC DISPLAY**
  On-Board CMOS IC
  Built-in RAM
  ASCII Decoder
  LED Drive Circuitry
- **128 ASCII CHARACTER SET**
- **16 USER DEFINABLE CHARACTERS**
- **PROGRAMMABLE FEATURES**
  Individual Flashing Character
  Full Display Blinking
  Multi-Level Dimming and Blanking
  Self Test
  Clear Function
- **READ/WRITE CAPABILITY**
- **FULL TTL COMPATIBILITY**
- **SINGLE 5 VOLT SUPPLY**
- **EXCELLENT ESD PROTECTION**
- **WAVE SOLDERABLE**
- **END STACKABLE**



Typical Applications

- **AVIONICS**
- **COMPUTER PERIPHERALS**
- **INDUSTRIAL INSTRUMENTATION**
- **MEDICAL EQUIPMENT**
- **PORTABLE DATA ENTRY DEVICES**
- **TELECOMMUNICATIONS**
- **TEST EQUIPMENT**

Description

The HDSP-2111 (yellow) and HDSP-2112 (high efficiency red) are eight-digit, 5 x 7 dot matrix, alphanumeric displays. The 5.0 mm (0.2 inch) high characters are packaged in a standard 15.24 mm (0.6 inch) 28 pin DIP. The on-board CMOS IC has the ability to decode 128 ASCII characters, which are permanently stored in ROM. In addition, 16 programmable symbols may be stored in on-board RAM. Seven brightness levels provide versatility in adjusting the display intensity and power consumption. The HDSP-211X is designed for standard microprocessor interface techniques. The display and special features are accessed through a bidirectional eight-bit data bus. These features make the HDSP-211X ideally suited for applications where a low cost, low power alphanumeric display is required.

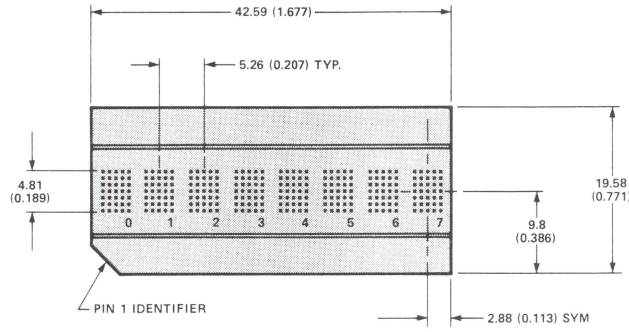
Absolute Maximum Ratings

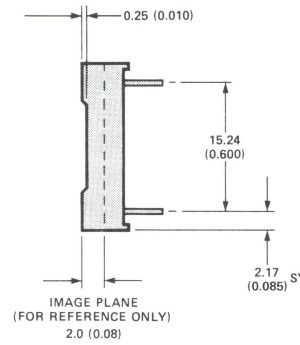
Supply Voltage, V_{CC} to Ground[1] . . . . . -0.3 to 7.0 V
Operating Voltage, V_{CC} to Ground[2] . . . . . 5.5 V
Input Voltage, Any Pin to Ground . . . . -0.3 to V_{CC} + 0.3 V
Free Air Operating Temperature
Range, T_A . . . . . -20° C to +70° C
Relative Humidity (non-condensing) 85%
Storage Temperature, T_S . . . . . -40° C to +85° C
Maximum Solder Temperature 1.59 mm (0.063 in.)
below Seating Plane, t < 5 sec . . . . . 260° C

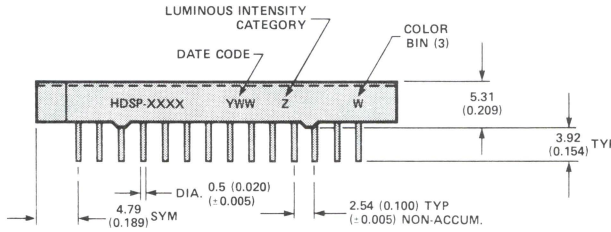
Notes:
1. Maximum Voltage is with no LEDs illuminated.
2. 20 dots on in all locations at full brightness.

ESD WARNING: STANDARD CMOS HANDLING PRECAUTIONS SHOULD BE OBSERVED WITH THE HDSP- 2111 AND HDSP-2112.

Package Dimensions



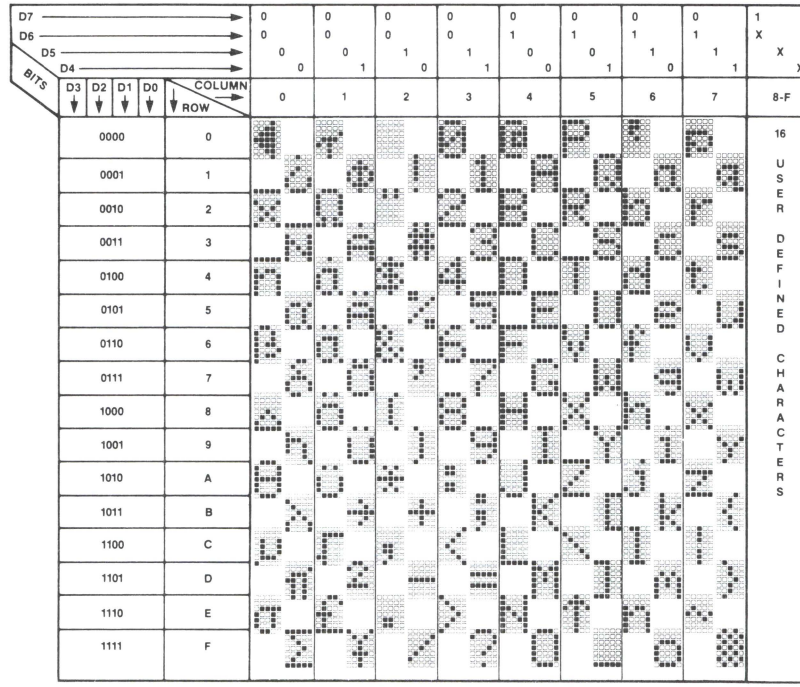




PIN NO.	FUNCTION	PIN NO.	FUNCTION
1	$\overline{RST}$	15	GND (SUPPLY)
2	$\overline{FL}$	16	GND (LOGIC)
3	A0	17	$\overline{CE}$
4	A1	18	$\overline{RD}$
5	A2	19	D0
6	A3	20	D1
7	SUBSTR. BIAS	21	NO PIN
8	SUBSTR. BIAS	22	NO PIN
9	SUBSTR. BIAS	23	D2
10	A4	24	D3
11	CLS	25	D4
12	CLK	26	D5
13	$\overline{WR}$	27	D6
14	VCC	28	D7

NOTES:
1. UNLESS OTHERWISE SPECIFIED, THE TOLERANCE ON ALL DIMENSIONS IS 0.254 mm (0.010 IN).
2. DIMENSIONS IN mm (INCHES).
3. FOR YELLOW ONLY.

Character Set



Recommended Operating Conditions

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.5	5.0	5.5	V

Electrical Characteristics Over Operating Temperature Range

4.5 < V_{CC} < 5.5 V (unless otherwise specified)

Parameter	Symbol	Min.	25° C Typ.[1]	25° C Max.[1]	Max.	Units	Test Conditions
Input Leakage (Input without pullup)	I_i				±1.0	μA	V_{in} = 0 to V_{CC} pins CLK, D_0-D_7, A_0-A_4
Input Current (input with pullup)	I_{ip}		11	18	30	μA	V_{in} = 0 to V_{CC} pins $\overline{RST}$, CLS, $\overline{WR}$, $\overline{RD}$, $\overline{CE}$, $\overline{FL}$
I_{CC} Blank	I_{CC} (BLK)		0.5	1.0	1.5	mA	V_{in} = 5.0 V
I_{CC} 8 digits 12 dots/character[2]	I_{CC}(V)		200	255	330	mA	"V" on in all 8 locations
I_{CC} 8 digits 20 dots/character[2]	I_{CC} (#)		300	370	430	mA	"#" on in all 8 locations
Input Voltage High	V_{ih}	2.0			V_{CC} +0.3 V	V	V_{CC} = 5.5 V
Input Voltage Low	V_{il}	GND -0.3 V			0.8	V	V_{CC} = 4.5 V
Output Voltage High	V_{oh}	2.4				V	V_{CC} = 4.5 V, I_{oh} = -40 μA
Output Voltage Low D_0-D_7	V_{ol}				0.4	V	V_{CC} = 4.5 V, I_{ol} = 1.6 mA
Output Voltage Low CLK					0.4	V	V_{CC} = 4.5 V, I_{ol} = 40 μA
Thermal Resistance IC Junction-to-Case	Θ_{j-c}		15			°C/W	

Notes:
1. V_{CC} = 5.0 V
2. Average I_{CC} measured at full brightness. See Table 2 in Control Word section for I_{CC} at lower brightness levels. Peak I_{CC} = 28/15 x Average I_{CC} (#).

Optical Characteristics at 25°C[3]

V_{CC} = 5.0 V, at Full Brightness

High Efficiency Red HDSP-2112

Description	Symbol	Min.	Typical	Max.	Units
Luminous Intensity Character average (#)	I_V	2.5	7.5		mcd
Peak Wavelength	λ(peak)		635		nm
Dominant Wavelength	λ(d)		626		nm

Yellow HDSP-2111

Description	Symbol	Min.	Typical	Max.	Units
Luminous Intensity Character average (#)	I_V	2.5	7.5		mcd
Peak Wavelength	λ(peak)		583		nm
Dominant Wavelength	λ(d)		585		nm

Note:
3. Refers to the initial case temperature of the device immediately prior to the light measurement.

AC Timing Characteristics Over Temperature Range

V_{CC} = 4.5 V

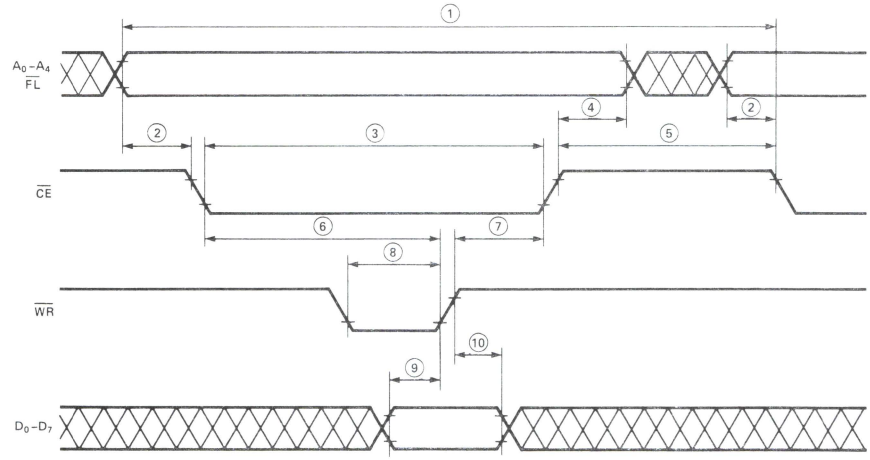
Reference number	Symbol	Description	Min.	Units
1	t_{acc}	Display Access Time Write Read	 210 230	 ns
2	t_{acs}	Address Setup Time to Chip Enable	10	ns
3	t_{ce}	Chip Enable Active Time Write Read	 140 160	 ns
4	t_{ach}	Address Hold Time to Chip Enable	20	ns
5	t_{cer}	Chip Enable Recovery Time	60	ns
6	t_{ces}	Chip Enable Active Prior to Rising Edge of Write Read	 140 160	 ns
7	t_{ceh}	Chip Enable Hold Time to Rising Edge of Read/Write Signal	0	ns
8	t_w	Write Active Time	100	ns
9	t_{wd}	Data Valid Prior to Rising Edge of Write Signal	50	ns
10	t_{dh}	Data Write Hold Time	20	ns
11	t_r	Chip Enable Active Prior to Valid Data	160	ns
12	t_{rd}	Read Active Prior to Valid Data	75	ns
13	t_{df}	Read Data Float Delay	10	ns
	t_{rc}	Reset Active Time	300	ns

V_{CC} = 4.5 to 5.5 V

Symbol	Description	25° C Typical	70° C Min.	Units
F_{osc}	Oscillator Frequency	57	28	kHz
F_{rf}[1]	Display Refresh Rate	256	128	Hz
F_{fl}[2]	Character Flash Rate	2	1	Hz
t_{st}[3]	Self Test Cycle Time	4.6	9.2	Sec

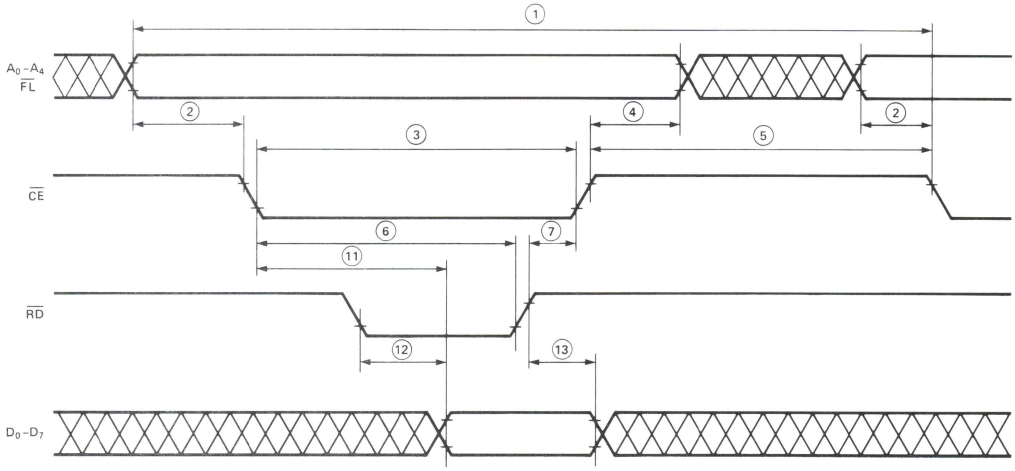
Notes:
1. $F_{rf} = F_{osc}/224$ 2. $F_{fl} = F_{osc}/28{,}672$ 3. $t_{st} = 262{,}144/F_{osc}$

Write Cycle Timing Diagram



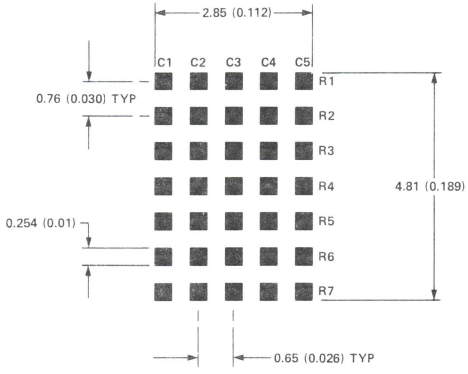
INPUT PULSE LEVELS – 0.6 V TO 2.4 V

Read Cycle Timing Diagram

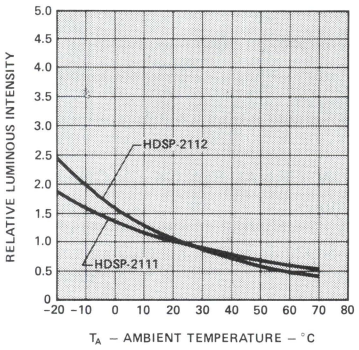


INPUT PULSE LEVELS: 0.6 V TO 2.4 V
OUTPUT REFERENCE LEVELS: 0.6 V TO 2.2 V
OUTPUT LOADING = 1 TTL LOAD AND 100pFd

Enlarged Character Font



Relative Luminous Intensity vs. Temperature



Electrical Description

PIN FUNCTION

RESET ($\overline{RST}$, pin 1)	Reset initializes the display.
FLASH ($\overline{FL}$, pin 2)	$\overline{FL}$ low indicates an access to the Flash RAM and is unaffected by the state of address lines A_3-A_4.
ADDRESS INPUTS (A_0-A_4, pins 3-6, 10)	Each location in memory has a distinct address. Address inputs (A_0-A_2) select a specific location in the Character RAM, the Flash RAM or a particular row in the UDC (User-Defined Character) RAM. A_3-A_4 are used to select which section of memory is accessed. Table 1 shows the logic levels needs to access each section of memory.

TABLE 1. LOGIC LEVELS TO ACCESS MEMORY

$\overline{F_L}$	A_4	A_3	Section of Memory	A_2 A_1 A_0
0	X	X	Flash RAM	Char. Address
1	0	0	UDC Address Register	Don't Care
1	0	1	UDC RAM	Row Address
1	1	0	Control Word Register	Don't Care
1	1	1	Character RAM	Char. Address

CLOCK SELECT (CLS, pin 11)	This input is used to select either an internal or external clock source.
CLOCK INPUT/OUTPUT (CLK, pin 12)	Outputs the master clock (CLS = 1) or inputs a clock (CLS = 0) for slave displays.
WRITE ($\overline{WR}$, pin 13)	Data is written into the display when the $\overline{WR}$ input is low and the $\overline{CE}$ input is low.
CHIP ENABLE ($\overline{CE}$, pin 17)	This input must be at a logic low to read or write data to the display and must go high between each read and write cycle.
READ ($\overline{RD}$, pin 18)	Data is read from the display when the $\overline{RD}$ input is low and the $\overline{CE}$ input is low.
DATA Bus (D_0-D_7, pins 19, 20, 23-28)	The Data bus is used to read from or write to the display.
$GND_{(SUPPLY)}$ (pin 15)	This is the analog ground for the LED drivers.
$GND_{(LOGIC)}$ (pin 16)	This is the digital ground for internal logic.
$V_{CC(POWER)}$ (pin 14)	This is the positive power supply input.
$V_{CC(SUBSTRATE)}$ (pins 7-9)	These pins are used to bias the IC substrate and must be connected to V_{CC}. These pins cannot be used to supply power to the display.

DISPLAY INTERNAL BLOCK DIAGRAM

Figure 1 shows the internal block diagram of the HDSP-211X display. The CMOS IC consists of an 8 byte Character RAM, an 8 bit Flash RAM, a 128 character ASCII decoder, a 16 character ASCII decoder, a 16 character UDC RAM, a UDC Address Register, a Control Word Register and the refresh circuitry necessary to synchronize the decoding and driving of eight 5 x 7 dot matrix characters. The major user accessible portions of the display are listed below:

Character RAM	This RAM stores either ASCII character data or a UDC RAM address.
Flash RAM	This is a 1 x 8 RAM which stores Flash data.
User-Defined Character RAM (UDC RAM)	This RAM stores the dot pattern for custom characters.
User-defined Character Address Register (UDC Address Register)	This register is used to provide the address to the UDC RAM when the user is writing or reading a custom character.
Control Word Register	This register allows the user to adjust the display brightness, flash individual characters, blink, self test or clear the display.

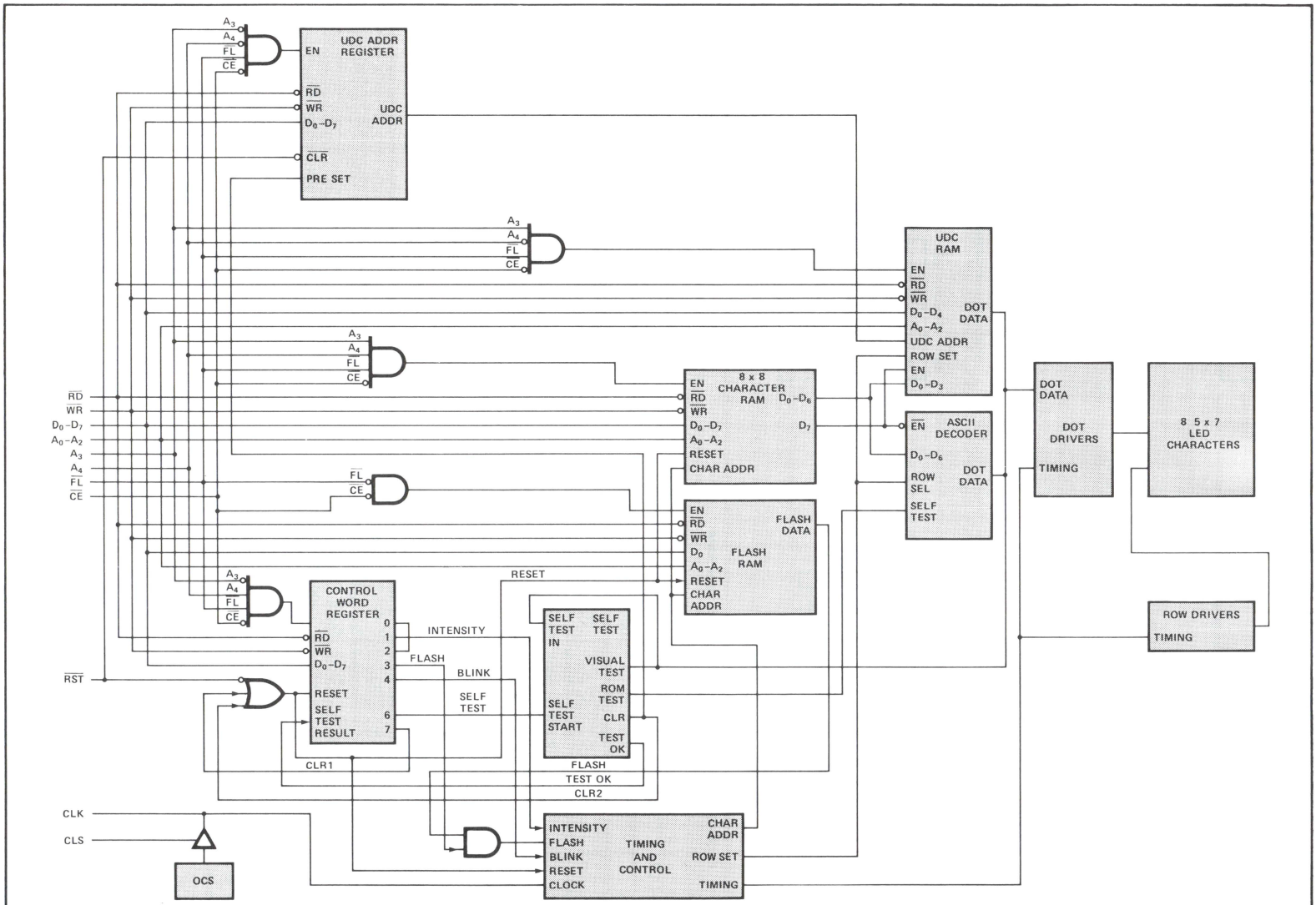


Figure 1. HDSP-211X Internal Block Diagram

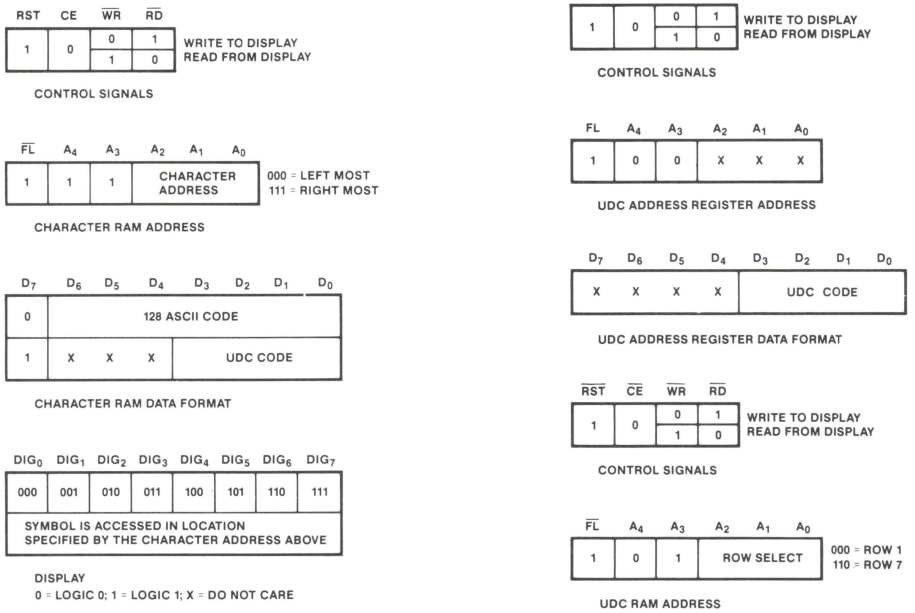


Figure 2. Logic Levels to Access the Character RAM

Figure 3. Logic Levels to Access a UDC Character

CHARACTER RAM

Figure 2 shows the logic levels needed to access the HDSP-211X Character RAM. Address lines A_0-A_2 are used to select the location in the Character RAM. Two types of data can be stored in each Character RAM location: an ASCII code or a UDC RAM address. Data bit D_7 is used to differentiate between an ASCII character and a UDC RAM address. D_7 = 0 enables the ASCII decoder and D_7 = 1 enables the UDC RAM. D_0-D_6 are used to input ASCII data and D_0-D_3 are used to input a UDC address.

UDC RAM AND UDC ADDRESS REGISTER

Figure 3 shows the logic levels needed to access the UDC RAM and the UDC Address Register. The UDC Address Register is eight bits wide. The lower four bits (D_0-D_3) are used to select one of the 16 UDC locations. The upper four bits (D_4-D_7) are not used. Once the UDC address has been stored in the UDC Address Register, the UDC RAM can be accessed.

To completely specify a 5 x 7 character requires eight write cycles. One cycle is used to store the UDC RAM address in the UDC Address Register. Seven cycles are used to store dot data in the UDC RAM. Data is entered by rows. One cycle is needed to access each row. Figure 4 shows the organization of a UDC character assuming the symbol to be stored is an "F". A_0-A_2 are used to select the row to be accessed and D_0-D_4 are used to transmit the row dot data. The upper three bits (D_5-D_7) are ignored. D_0 (least significant bit) corresponds to the right most column of the 5 x 7 matrix and D_4 (most significant bit) corresponds to the left most column of the 5 x 7 matrix.

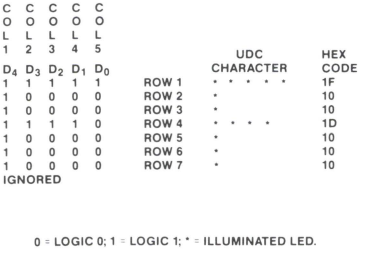


Figure 4. Data to Load "F" into the UDC RAM

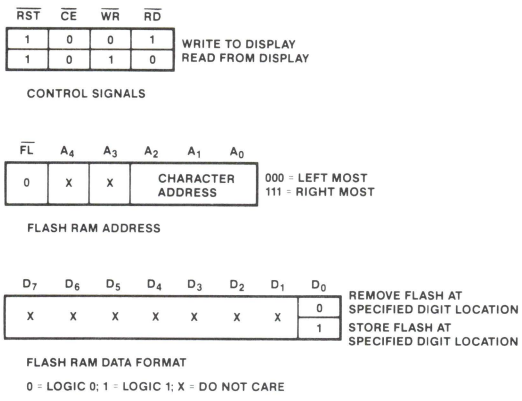


Figure 5. Logic Levels to Access the Flash RAM

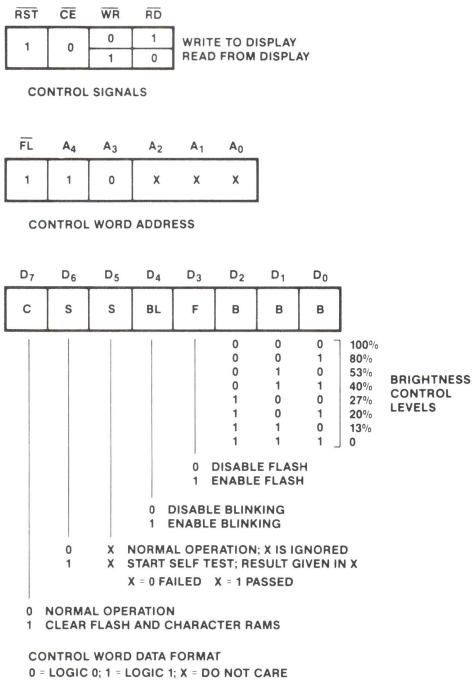


Figure 6. Logic Levels to Access the Control Word Register

FLASH RAM

Figure 5 shows the logic levels needed to access the Flash RAM. The Flash RAM has one bit associated with each location of the Character RAM. The Flash input is used to select the Flash RAM. Address lines A_3-A_4 are ignored. Address lines A_0-A_2 are used to select the location in the Flash RAM to store the attribute. D_0 is used to store or remove the flash attribute. D_0 = "1" stores the attribute and D_0 = "0" removes the attribute.

When the attribute is enabled through bit 3 of the Control Word and a "1" is stored in the Flash RAM, the corresponding character will flash at approximately 2 Hz. The actual rate is dependent on the clock frequency. For an external clock the flash rate can be calculated by dividing the clock frequency by 28,672.

Control Word Register

Figure 6 shows how to access the Control Word Register. This is an eight bit register which performs five functions. They are Brightness control, Flash RAM control, Blinking, Self Test and Clear. Each function is independent of the others. However, all bits are updated during each Control Word write cycle.

BRIGHTNESS (BITS 0-2)

Bits 0-2 of the Control Word adjust the brightness of the display. Bits 0-2 are interpreted as a three bit binary code with code (000) corresponding to maximum brightness and code (111) corresponding to a blanked display. In addition to varying the display brightness, bits 0-2 also vary the average value of I_{CC}. I_{CC} can be calculated at any brightness level by multiplying the percent brightness level by the value of I_{CC} at the 100% brightness level. These values of I_{CC} are shown in Table 2.

FLASH FUNCTION (BIT 3)

Bit 3 determines whether the flashing character attribute is on or off. When bit 3 is a "1", the output of the Flash RAM is checked. If the content of a location in the Flash RAM is a "1", the associated digit will flash at approximately 2 Hz. For an external clock, the blink rate can be calculated by diving the clock frequency by 28,672. If the flash enable bit of the Control Word is a "0", the content of the Flash RAM is ignored. To use this function with multiple display systems see the Reset section.

TABLE 2. CURRENT REQUIREMENTS AT DIFFERENT BRIGHTNESS LEVELS

Symbol	D_2 D_1 D_0	% Brightness	25° C Typ.	Units
I_{CC}(V)	0 0 0	100	200	mA
	0 0 1	80	160	mA
	0 1 0	53	106	mA
	0 1 1	40	80	mA
	1 0 0	27	54	mA
	1 0 1	20	40	mA
	1 1 0	13	26	mA

BLINK FUNCTION (BIT 4)

Bit 4 of the Control Word is used to synchronize blinking of all eight digits of the display. When this bit is a "1" all eight digits of the display will blink at approximately 2 Hz. The actual rate is dependent on the clock frequency. For an external clock, the blink rate can be calculated by dividing

the clock frequency by 28,672. This function will overrride the Flash function when it is active. To use this function with multiple display systems see the Reset section.

SELF TEST FUNCTION (BITS 5,6)

Bit 6 of the Control Word Register is used to initiate the self test function. Results of the internal self test are stored in bit 5 of the Control Word. Bit 5 is a read only bit where bit 5 = "1" indicates a passed self test and bit 5 = "0" indicates a failed self test.

Setting bit 6 to a logic 1 will start the self test function. The built-in self test function of the IC consists of two internal routines which exercises major portions of the IC and illuminates all of the LEDs. The first routine cycles the ASCII decoder ROM through all states and performs a checksum on the output. If the checksum agrees with the correct value, bit 5 is set to "1". The second routine provides a visual test of the LEDs using the drive cicuitry. This is accomplished by writing checkered and inverse checkered patterns to the display. Each pattern is displayed for approximately 2 seconds.

During the self test function the display must not be accessed. The time needed to execute the self test function is calculated by multiplying the clock period by 262,144. For example: assume a clock frequency of 58 KHz, then the time to execute the self test function frequency is equal to (262,144/58,000) = 4.5 second duration.

At the end of the self test function, the Character RAM is loaded with blanks, the Control Word Register is set to zeros except for bit 5, and the Flash RAM is cleared and the UDC Address Register is set to all ones.

CLEAR FUNCTION (BIT 7)

Bit 7 of the Control Word will clear the Character RAM and Flash RAM. The ASCII character code for a space will be loaded into the Character RAM to blank the display. The UDC RAM, UDC Address Register and the remainder of the Control Word are unaffected.

Display Reset

Figure 7 shows the logic levels needed to Reset the display. The display should be Reset on power-up. The external Reset clears the Character RAM, Flash RAM, Control Word Register and resets the internal counters. All displays which operate with the same clock source must be simultaneously reset to synchronize the Flashing and Blinking functions.

$\overline{RST}$	$\overline{CE}$	$\overline{WR}$	$\overline{RD}$	$\overline{FL}$	A_4-A_0	D_7-D_0
0	1	X	X	X	X	X

0 = LOGIC 0; 1 = LOGIC 1; X = DO NOT CARE

NOTE:
IF RST, CE AND WR ARE LOW, UNKNOWN DATA MAY BE WRITTEN INTO THE DISPLAY.

Figure 7. Logic Levels to Reset the Display

Mechanical and Electrical Considerations

The HDSP-211X is a 28 pin dual-in-line package with 26 external pins, which can be stacked horizontally and vertically to create arrays of any size. The HDSP-211X is designed to operate continuously from -20°C to +70°C with a maximum of 20 dots on per character. Illuminating all thirty-five dots at full brightness is not recommended.

The HDSP-211X is assembled by die attaching and wire bonding 280 LED chips and a CMOS IC to a thermally conductive printed circuit board. A polycarbonate lens is placed over the PC board creating an air gap over the LED wire bonds. A protective cap creates an air gap over the CMOS IC. Backfill epoxy environmentally seals the display package. This package construction makes the display highly tolerant to temperature cycling and allows wave soldering.

The inputs to the IC are protected against static discharge and input current latchup. However, for best results standard CMOS handling precautions should be used. Prior to use, the HDSP-211X should be stored in antistatic tubes or in conductive material. During assembly, a grounded conductive work area should be used, and assembly personnel should wear conductive wrist straps. Lab coats made of synthetic material should be avoided since they are prone to static build-up. Input current latchup is caused when the CMOS inputs are subjected to either a voltage below ground (V_{in} < ground) or to a voltage higher than V_{CC} (V_{in} > V_{CC}), and when a high current is forced into the input. To prevent input current latchup and ESD damage, unused inputs should be connected either to ground or to V_{CC}. Voltages should not be applied to the inputs until V_{CC} has been applied to the display.

Thermal Considerations

The HDSP-211X has been designed to provide a low thermal resistance path for the CMOS IC to the 26 package pins. This heat is then typically conducted through the traces of the printed circuit board to free air. For most applications no additional heatsinking is required.

Measurements were made on a 32 character display string to determine the thermal resistance of the display assembly. Several display boards were constructed using 62 mil printed circuit material, and 1 ounce copper 20 mil traces. Some of the device pins were connected to a heatsink formed by etching a copper area on the printed circuit board surrounding the display. A maximum metalized printed circuit board was also evaluated. The junction temperature was measured for displays soldered directly to these PC boards, displays installed in sockets, and finally displays installed in sockets with a filter over the display to restrict airflow. The results of these thermal resistance measurements, Θ_{ja}, are shown in Table 3 and include the affects of Θ_{jc}.

TABLE 3. THERMAL RESISTANCE, Θ_{ja}, USING VARIOUS AMOUNTS OF HEATSINKING MATERIAL.

Heatsinking Metal per device sq. in.	W/Sockets W/O Filter (avg.)	W/O Sockets W/O Filter (avg.)	W/Sockets W/Filter (avg.)	units
0	31	30	35	°C/W
1	31	28	33	°C/W
3	30	26	33	°C/W
Max. Metal	29	25	32	°C/W
4 board avg.	30	27	33	°C/W

Ground Connections

Two ground pins are provided to keep the internal IC logic ground clean. The designer can, when necessary, route the analog ground for the LED drivers separately from the logic ground until an appropriate ground plane is available. On long interconnects between the display and the host system, the designer can keep voltage drops on the analog ground from affecting the display logic levels by isolating the two grounds.

The logic ground should be connected to the same ground potential as the logic interface circuitry. The analog ground and the logic ground should be connected at a common ground which can withstand the current introduced by the switching LED drivers. When separate ground connections are used, the analog ground can vary from -0.3 V to +0.3 V with respect to the logic ground. Voltage below -0.3 V can cause all dots to be on. Voltage above +0.3 V can cause dimming and dot mismatch.

Soldering and Post Solder Cleaning Instructions for the HDSP-211X

The HDSP-211X may be hand soldered or wave soldered with SN63 solder. When hand soldering it is recommended that an electronically temperature controlled and securely grounded soldering iron be used. For best results, the iron tip temperature should be set at 315°C (600°F). For wave soldering, a rosin-based RMA flux can be used. The solder wave temperature should be set at 245°C ±5°C (473°F ±9°F), and the dwell in the wave should be set between 1½ to 3 seconds for optimum soldering. The preheat temperature should not exceed 105°C (221°F) as measured on the solder side of the PC board.

Post solder cleaning may be performed with a solvent or aqueous process. For solvent cleaning, Allied Chemical's Genesolv DES, Baron Blakeslee's Blaco-Tron TES or DuPont's Freon TE may be used. These solvents are azeotropes of trichlorotrifluoroethane FC-113 with low concentrations of ethanol (5%). The maximum exposure time in the solvent vapors at boiling temperature should not exceed 2 minutes. Solvents containing high concentrations of alcohols such as methanol, ketones such as acetone, or chlorinated solvents should not be used as they will chemically attack the polycarbonate lens. Solvents containing trichloroethylene FC-111 or FC-112 and trichloroethylene (TCE) are also not recommended.

An aqueous cleaning process may be used. A saponifier, such as Kesterbio-kleen Formula 5799 or its equivalent, may be added to the wash cycle of an aqueous process to remove rosin flux residues. Organic acid flux residues must be thoroughly removed by an aqueous cleaning process to prevent corrosion of the leads and solder connections. The optimum water temperature is 60°C (140°F). The maximum cumulative exposure of the HDSP-211X to wash and rinse cycles should not exceed 15 minutes. For additional information on soldering and post solder cleaning, see Application Note 1027.

Contrast Enhancement

The objective of contrast enhancement is to provide good readability in the end user's ambient lighting conditions. The concept is to employ both luminance and chrominance contrast techniques. These enhance readability by having the OFF-dots blend into the display background and the ON-dots vividly stand out against the same background. Contrast enhancement may be achieved by using one of the following suggested filters:

HDSP-2112
Panelgraphic SCARLET RED 65 or GRAY 10
SGL Homalite H100-1670 RED or -1265 GRAY
3M Louvered Filter R6310 RED or N0210 GRAY

HDSP-2111
Panelgraphic AMBER 23 or GRAY 10
SGL Homalite H100-1720 AMBER or -1265 GRAY
3M Louvered Filter N0210 GRAY

For additional information on contrast enhancement see Application Note 1015.

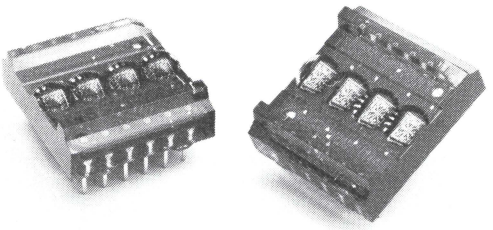
HEWLETT PACKARD

FOUR CHARACTER 2.85mm (0.112 in.) SMART ALPHANUMERIC DISPLAY

HPDL-1414

Features

- **SMART ALPHANUMERIC DISPLAY**
  Built-in RAM, ASCII Decoder and LED Drive Circuitry
- **WIDE OPERATING TEMPERATURE RANGE**
  –40° C to +85° C
- **FAST ACCESS TIME**
  160 ns
- **EXCELLENT ESD PROTECTION**
  Built-in Input Protection Diodes
- **CMOS IC FOR LOW POWER CONSUMPTION**
- **FULL TTL COMPATIBILITY OVER OPERATING TEMPERATURE RANGE**
  V_{IL} = 0.8 V
  V_{IH} = 2.0 V
- **WAVE SOLDERABLE**
- **RUGGED PACKAGE CONSTRUCTION**
- **END-STACKABLE**
- **WIDE VIEWING ANGLE**



Typical Applications

- **PORTABLE DATA ENTRY DEVICES**
- **MEDICAL EQUIPMENT**
- **PROCESS CONTROL EQUIPMENT**
- **TEST EQUIPMENT**
- **INDUSTRIAL INSTRUMENTATION**
- **COMPUTER PERIPHERALS**
- **TELECOMMUNICATION INSTRUMENTATION**

Description

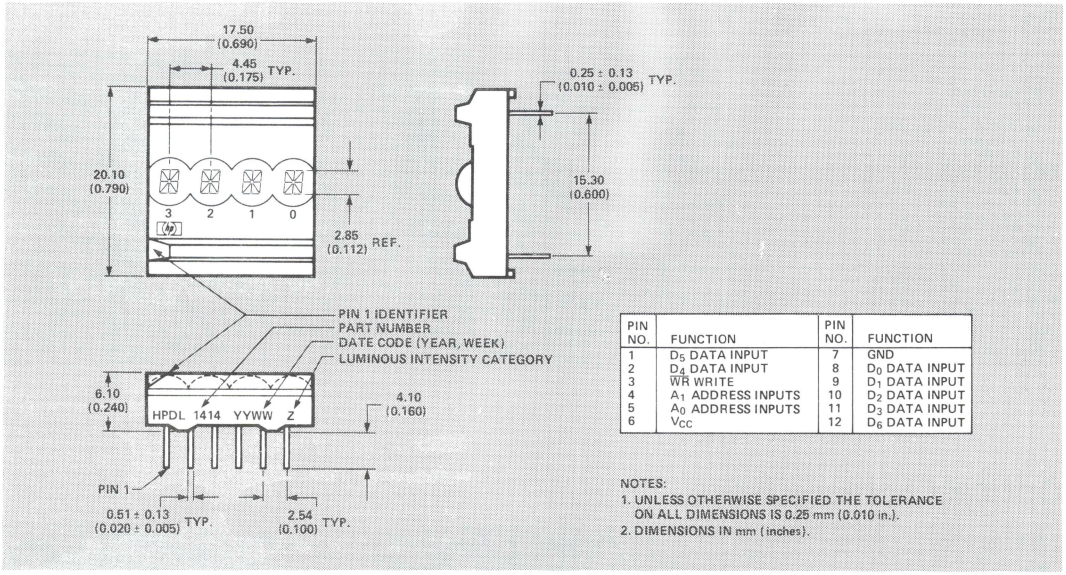
The HPDL-1414 is a smart 2.85 mm (0.112") four character, sixteen-segment, red GaAsP display. The on-board CMOS IC contains memory, ASCII decoder, multiplexing circuitry and drivers. The monolithic LED characters are magnified by an immersion lens which increases both character size and luminous intensity. The encapsulated dual-in-line package provides a rugged, environmentally sealed unit.

The HPDL-1414 incorporates many improvements over competitive products. It has a wide operating temperature range, very fast IC access time and improved ESD protection. The display is also fully TTL compatible, wave solderable and highly reliable. This display is ideally suited for industrial and commercial applications where a good-looking, easy-to-use alphanumeric display is required.

Absolute Maximum Ratings

Supply Voltage, V_{CC} to Ground ..... –0.5 V to 7.0 V
Input Voltage, Any Pin to Ground .... –0.5 V to V_{CC} +0.5 V
Free Air Operating
Temperature Range, T_A ..... –40° C to +85° C
Relative Humidity (non-condensing) at 65° C 90%
Storage Temperature, T_S ..... –40° C to +85° C
Maximum Solder Temperature, 1.59 mm (0.063 in.)
below Seating Plane, t< 5 sec. ..... 260° C

Package Dimensions



PIN NO.	FUNCTION	PIN NO.	FUNCTION
1	D_5 DATA INPUT	7	GND
2	D_4 DATA INPUT	8	D_0 DATA INPUT
3	$\overline{WR}$ WRITE	9	D_1 DATA INPUT
4	A_1 ADDRESS INPUTS	10	D_2 DATA INPUT
5	A_0 ADDRESS INPUTS	11	D_3 DATA INPUT
6	V_{CC}	12	D_6 DATA INPUT

NOTES:
1. UNLESS OTHERWISE SPECIFIED THE TOLERANCE ON ALL DIMENSIONS IS 0.25 mm (0.010 in.).
2. DIMENSIONS IN mm (inches).

Recommended Operating Conditions

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Input Voltage High	V_{IH}	2.0			V
Input Voltage Low	V_{IL}			0.8	V

DC Electrical Characteristics Over Operating Temperature Range

TYPICAL VALUES

Parameter	Symbol	Units	–40° C	–20° C	25° C	85° C	Test Condition
I_{CC} 4 digits on (10 seg/digit)[1,2]	I_{CC}	mA	90	85	70	60	V_{CC} = 5.0 V
I_{CC} Blank	I_{CC} ($\overline{BL}$)	mA	1.8	1.5	1.2	1.1	V_{CC} = 5.0 V $\overline{BL}$ = 0.8 V
Input Current, Max.	I_{IL}	μA	23	20	17	12	V_{CC} = 5.0 V V_{IN} = 0.8 V

GUARANTEED MAXIMUM VALUES

Parameter	Symbol	Units	25° C V_{CC} = 5.0 V	Maximum Over Operating Temperature Range V_{CC} = 5.5 V
I_{CC} 4 digits on (10 seg/digit)[1,2]	I_{CC}	mA	90	130
I_{CC} Blank	I_{CC} ($\overline{BL}$)	mA	2.3	4.0
Input Current, Max.	I_{IL}	μA	30	50
Power Dissipation[3]	P_D	mW	450	715

Notes:
1. "%" illuminated in all four characters.
2. Measured at five seconds.
3. Power dissipation = $V_{CC} \cdot I_{CC}$ (10 seg.).

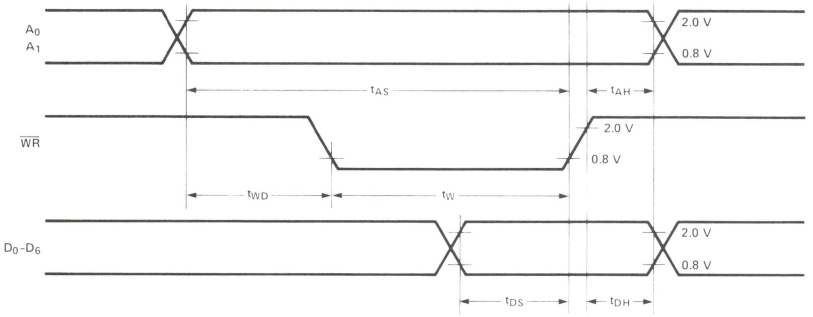
AC Timing Characteristics Over Operating Temperature Range at V_{CC} = 4.5 V

Parameter	Symbol	−20° C t_{MIN}	25° C t_{MIN}	70° C t_{MIN}	Units
Address Setup Time	t_{AS}	90	115	150	ns
Write Delay Time	t_{WD}	10	15	20	ns
Write Time	t_W	80	100	130	ns
Data Setup Time	t_{DS}	40	60	80	ns
Data Hold Time	t_{DH}	40	45	50	ns
Address Hold Time	t_{AH}	40	45	50	ns
Access Time		130	160	200	ns
Refresh Rate		420-790	310-630	270-550	Hz

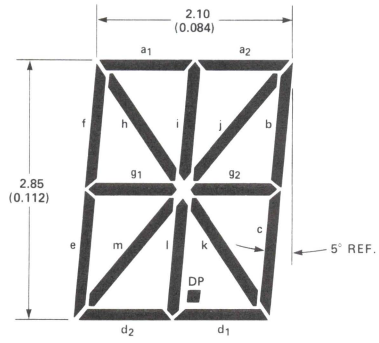
Optical Characteristics

Parameter	Symbol	Test Condition	Min.	Typ.	Units
Peak Luminous Intensity per digit, 8 segments on (character average)	Iv Peak	V_{CC} = 5.0 V "8" illuminated in all 4 digits.	0.4	1.0	mcd
Peak Wavelength	λpeak			655	nm
Dominant Wavelength	λd			640	nm
Off Axis Viewing Angle				±40	degrees
Digit Size				2.85	mm

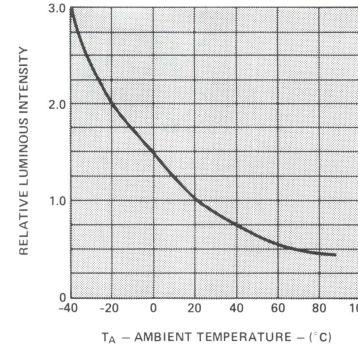
Timing Diagram



Magnified Character Font Description



Relative Luminous Intensity vs. Temperature



Electrical Description

Figure 1 shows the internal block diagram of the HPDL-1414. It consists of two parts: the display LEDs and the CMOS IC. The CMOS IC consists of a four-word ASCII memory, a 64-word character generator, 17 segment drivers, four digit drivers, and the scanning circuitry necessary to multiplex the four monolithic LED characters. In normal operation, the divide-by-four counter sequentially accesses each of the four RAM locations and simultaneously enables the appropriate display digit driver. The output of the RAM is decoded by the character generator which, in turn, enables the appropriate display segment drivers. Seven-bit ASCII data is stored in RAM. Since the display uses a 64-character decoder, half of the possible 128 input combinations are invalid. For each display location where D5=D6 in the ASCII RAM, the display character is blanked.

Data is loaded into the display through the DATA inputs (D_6-D_0), ADDRESS inputs (A_1-A_0), and WRITE ($\overline{WR}$). After a character has been written to memory, the IC decodes the ASCII data, drives the display and refreshes it without any external hardware or software.

The HPDL-1414 uses 12 pins to control the CMOS IC. Figure 1 shows the effect these inputs have on the display.

DATA INPUTS (D_0-D_6, pins 1, 2, 8-12)	Seven bit ASCII data is entered into memory via the DATA inputs.
ADDRESS INPUTS (A_1-A_0, pins 4 and 5)	Each location in memory has a distinct address. ADDRESS inputs enable the designer to select a specific location in memory to store data. Address 00 accesses the far right display location. Address 11 accesses the far left location.
WRITE ($\overline{WR}$, pin 3)	Data is written into the display when the $\overline{WR}$ input is low.
V_{CC} and GND (pins 6 and 7)	These pins supply power to the display.

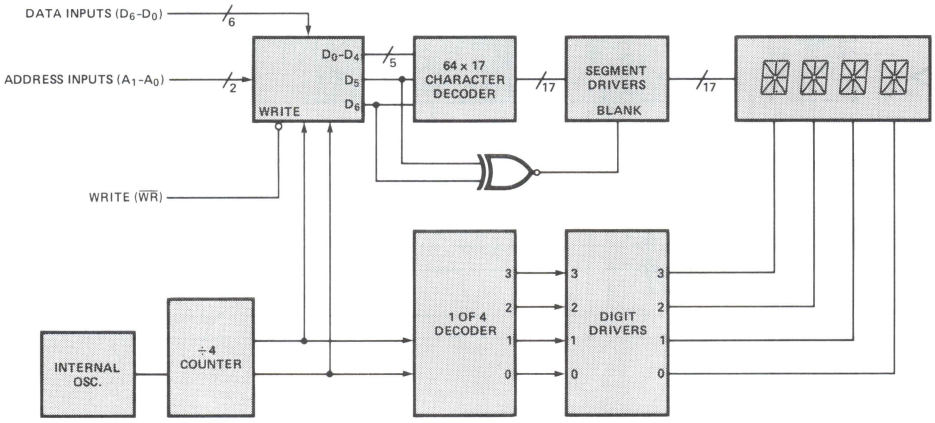


Figure 1. HPDL-1414 Internal Block Diagram

$\overline{WR}$	A_1	A_0	D_6	D_5	D_4	D_3	D_2	D_1	D_0	DIG_3	DIG_2	DIG_1	DIG_0
L	L	L	a	a	a	a	a	a	a	NC	NC	NC	A
L	L	H	b	b	b	b	b	b	b	NC	NC	B	NC
L	H	L	c	c	c	c	c	c	c	NC	C	NC	NC
L	H	H	d	d	d	d	d	d	d	D	NC	NC	NC
H	X	X	X	X	X	X	X	X	X	Previously Written Data			

L = LOGIC LOW INPUT
H = LOGIC HIGH INPUT
X = DON'T CARE

"a" = ASCII CODE CORRESPONDING TO SYMBOL "A"
NC = NO CHANGE

Figure 2. Write Truth Table

Using the HPDL-1414 with Microprocessors

Figures 3 and 4 show how to connect the HPDL-1414 to a Motorola 6800 or an Intel 8085. The major differences between the two circuits are:

1. The 6800 requires two latches to store the ADDRESS and ASCII DATA information to increase the address and data input hold times.
2. The 6800 requires a flip-flop to delay the display WRITE signal to increase the address input setup time.

ADDRESS inputs (A_1 and A_0) are connected to microprocessor addresses A_1 and A_0. A 74LS138 may be used to generate individual display WRITE signals. Higher order microprocessor address lines are connected to the 74LS138. The microprocessor write line must be wired to one of the active low enable inputs of the 74LS138. Both figures are formatted with address 0 being the far right display character.

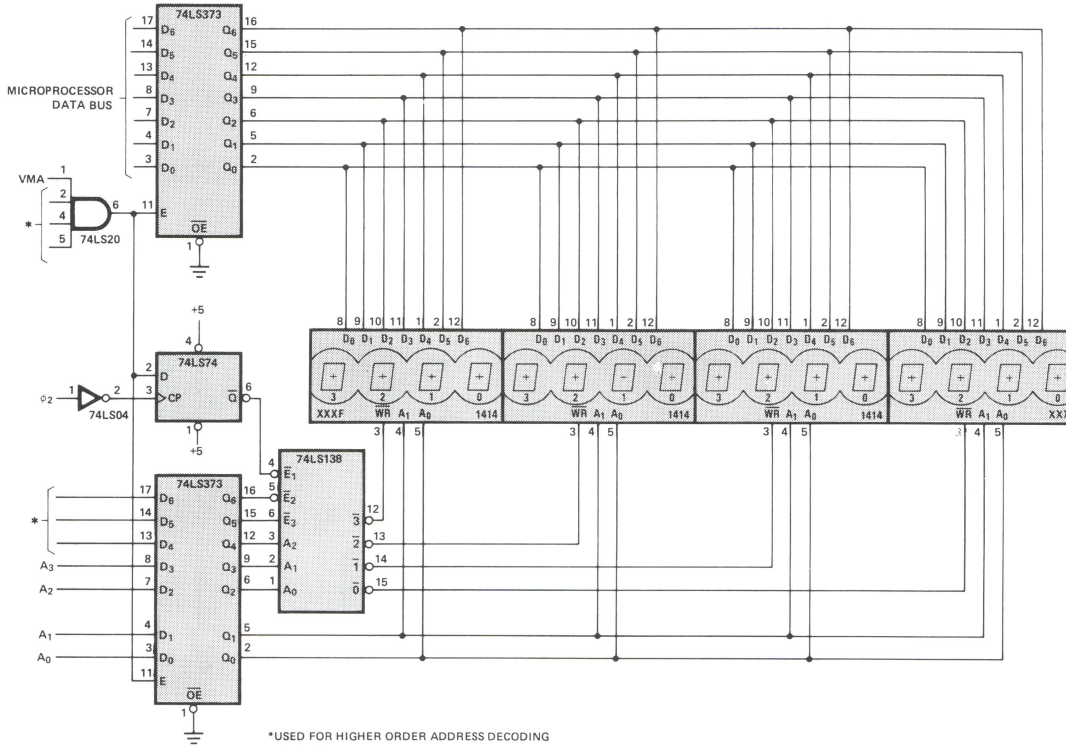


Figure 3: Memory Mapped Interface for the 6800

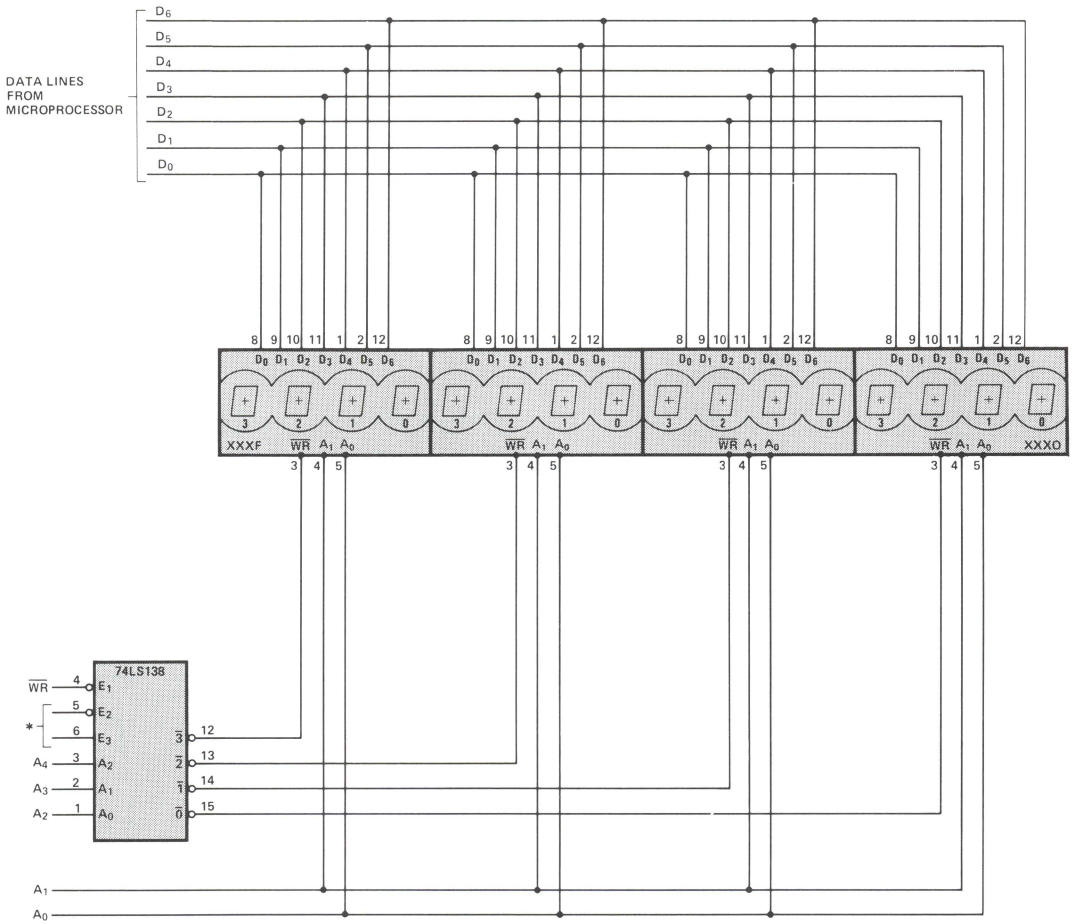


Figure 4. Memory Mapped Interface for the 8085

BITS	D_3 D_2 D_1 D_0	0 0 0 0	0 0 0 1	0 0 1 0	0 0 1 1	0 1 0 0	0 1 0 1	0 1 1 0	0 1 1 1	1 0 0 0	1 0 0 1	1 0 1 0	1 0 1 1	1 1 0 0	1 1 0 1	1 1 1 0	1 1 1 1
D_6 D_5 D_4	HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0 1 0	2	(space)	!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
0 1 1	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
1 0 0	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1 0 1	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_

Figure 5. HPDL-1414 ASCII Character Set

Mechanical and Electrical Considerations

The HPDL-1414 is a 12 pin dual-in-line package which can be stacked horizontally and vertically to create arrays of any size. The HPDL-1414 is designed to operate continuously from −40° C to +85° C for all possible input conditions.

The HPDL-1414 is assembled by die attaching and wire bonding the four GaAsP/GaAs monolithic LED chips and the CMOS IC to a high temperature printed circuit board. An immersion lens is formed by placing the PC board assembly into a nylon lens filled with epoxy. A plastic cap creates an air gap to protect the CMOS IC. Backfill epoxy environmentally seals the display package. This package construction gives the display a high tolerance to temperature cycling.

The inputs to the CMOS IC are protected against static discharge and input current latchup. However, for best results, standard CMOS handling precautions should be used. Prior to use, the HPDL-1414 should be stored in anti-static tubes or conductive material. A grounded conductive assembly area should be used, and assembly personnel should wear conductive wrist straps. Lab coats made of synthetic materials should be avoided since they may collect a static charge. Input current latchup is caused when the CMOS inputs are subjected either to a voltage below ground (V_{IN} < ground) or to a voltage higher than V_{CC} (V_{IN} > V_{CC}), and when a high current is forced into the input.

Soldering and Post Solder Cleaning Instructions for the HPDL-1414

The HPDL-1414 may be hand soldered or wave soldered with SN63 solder. Hand soldering may be safely performed only with an electronically temperature-controlled and securely grounded soldering iron. For best results, the iron tip temperature should be set at 315° C (600° F). For wave soldering, a rosin-based RMA flux or a water soluble organic acid (OA) flux can be used. The solder wave temperature should be 245° C ±5° C (473° F ±9° F), and the dwell in the wave should be set at 1 1/2 to 3 seconds for optimum soldering. Preheat temperature should not exceed 93° C (200° F) as measured on the solder side of the PC board.

Post solder cleaning may be performed with a solvent or aqueous process. For solvent cleaning, Allied Chemical Genesolv DES, Baron Blakeslee Blaco-Tron TES or DuPont Freon TE can only be used. These solvents are azeotropes of trichlorotrifluoroethane FC-113 with low concentrations of ethanol (5%). The maximum exposure time in the solvent vapors at boiling temperature should not exceed 2 minutes. Solvents containing high concentrations of alcohols, pure alcohols, isopropanol or acetone should not be used as they will chemically attack the nylon lens. Solvents containing trichloroethane FC-111 or FC-112 and trichloroethylene (TCE) are not recommended.

An aqueous cleaning process is highly recommended. A saponifier, such as Kester Bio-kleen Formula 5799 or equivalent, may be added to the wash cycle of an aqueous process to remove rosin flux residues. Organic acid flux residues must be thoroughly removed by an aqueous cleaning process to prevent corrosion of the leads and solder connections. The optimum water temperature is 60° C (140° F). The maximum cumulative exposure of the HPDL-1414 to wash and rinse cycles should not exceed 15 minutes.

Optical Considerations/ Contrast Enhancement

The HPDL-1414 display uses a precision aspheric immersion lens to provide excellent readability and low off-axis distortion. The aspheric lens produces a magnified character height of 2.85 mm (0.112 in.) and a viewing angle of ±40 degrees. These features provide excellent readability at distances of up to 1.5 meters (4 feet).

Each HPDL-1414 display is tested for luminous intensity and marked with an intensity category on the side of the display package. To ensure intensity matching for multiple package applications, mixing intensity categories for a given panel is not recommended.

The HPDL-1414 display is designed to provide maximum contrast when placed behind an appropriate contrast enhancement filter. Some suggested filters are Panelgraphic Ruby Red 60, Panelgraphic Dark Red 63, SGL Homalite H100-1650, Rohm and Haas 2423, Chequers Engraving 118, and 3M R6510. For further information on contrast enhancement, see Hewlett-Packard Application Note 1015.

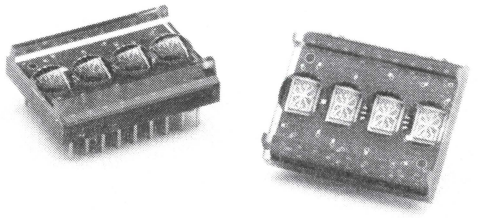
HEWLETT PACKARD

FOUR CHARACTER 4.1 mm (0.16 in.) SMART ALPHANUMERIC DISPLAY

HPDL-2416

Features

- **SMART ALPHANUMERIC DISPLAY**
  Built-in RAM, ASCII Decoder, and LED Drive Circuitry
- **WIDE OPERATING TEMPERATURE RANGE**
  –40° C to +85° C
- **VERY FAST ACCESS TIME**
  160 ns
- **EXCELLENT ESD PROTECTION**
  Built-in Input Protection Diodes
- **CMOS IC FOR LOW POWER CONSUMPTION**
- **FULL TTL COMPATIBILITY OVER OPERATING TEMPERATURE RANGE**
  V_{IL} = 0.8 V
  V_{IH} = 2.0 V
- **WAVE SOLDERABLE**
- **RUGGED PACKAGE CONSTRUCTION**
- **END-STACKABLE**
- **WIDE VIEWING ANGLE**



Typical Applications

- **PORTABLE DATA ENTRY DEVICES**
- **MEDICAL EQUIPMENT**
- **PROCESS CONTROL EQUIPMENT**
- **TEST EQUIPMENT**
- **INDUSTRIAL INSTRUMENTATION**
- **COMPUTER PERIPHERALS**
- **TELECOMMUNICATION EQUIPMENT**

Description

The HPDL-2416 has been designed to incorporate several improvements over competitive products. It has a wide operating temperature range, fast IC access time and improved ESD protection. The HPDL-2416 is fully TTL compatible, wave solderable, and highly reliable. This display is ideally suited for industrial and commercial applications where a good looking, easy-to-use alphanumeric display is required.

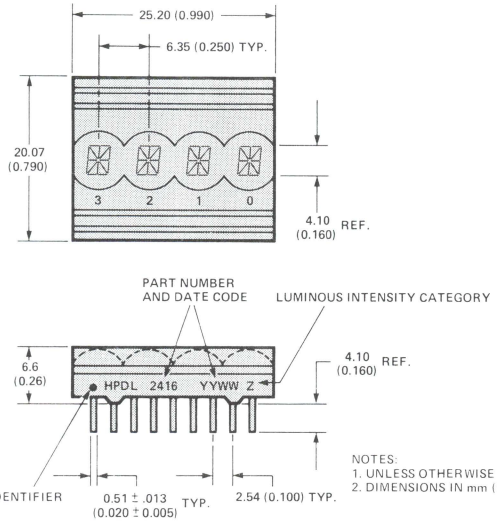
The HPDL-2416 is a smart 4.1 mm (0.16 in) four character, sixteen-segment red GaAsP display. The on-board CMOS IC contains memory, ASCII decoder, multiplexing circuitry, and drivers. The monolithic LED characters are magnified by an immersion lens which increases both character size and luminous intensity. The encapsulated dual-in-line package construction provides a rugged, environmentally sealed unit.

Absolute Maximum Ratings

Supply Voltage, V_{CC} to Ground ..... –0.5 V to 7.0 V
Input Voltage, Any Pin to Ground ... –0.5 V to V_{CC} +0.5 V
Free Air Operating, No Cursors On[1]
  Temperature Range, T_A ..... –40° C to +85° C
Relative Humidity (non-condensing) at 65° C 90%
Storage Temperature, T_S ..... –40° C to +85° C
Maximum Solder Temperature, 1.59 mm (0.063 in.)
  below Seating Plane, t ≤ 5 sec. ..... 260° C

Note:
1. Free air operating temperature range.
   T_A > 75° C No Cursors On
   T_A ≤ 75° C 1 Cursor On
   T_A ≤ 68° C 2 Cursors On
   T_A ≤ 60° C 3 Cursors On
   T_A ≤ 55° C 4 Cursors On

Package Dimensions



PIN NO.	FUNCTION	PIN NO.	FUNCTION
1	$\overline{CE}_1$ CHIP ENABLE	10	GND
2	$\overline{CE}_2$ CHIP ENABLE	11	D_0 DATA INPUT
3	$\overline{CLR}$ CLEAR	12	D_1 DATA INPUT
4	$\overline{CUE}$ CURSOR ENABLE	13	D_2 DATA INPUT
5	$\overline{CU}$ CURSOR SELECT	14	D_3 DATA INPUT
6	$\overline{WR}$ WRITE	15	D_6 DATA INPUT
7	ADDRESS INPUT A_1	16	D_5 DATA INPUT
8	ADDRESS INPUT A_0	17	D_4 DATA INPUT
9	V_{CC}	18	$\overline{BL}$ DISPLAY BLANK

NOTES:
1. UNLESS OTHERWISE SPECIFIED, THE TOLERANCE ON ALL DIMENSIONS IS 0.254 mm (0.010 IN.)
2. DIMENSIONS IN mm (INCHES).

Recommended Operating Conditions

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Input Voltage High	V_{IH}	2.0			V
Input Voltage Low	V_{IL}			0.8	V

DC Electrical Characteristics Over Operating Temperature Range

TYPICAL VALUES

Parameter	Symbol	Units	-40°C	-20°C	25°C	70°C	85°C	Test Condition
I_{CC} 4 digits on (10 seg/digit) [1,2]	I_{CC}	mA	100	95	85	75	72	V_{CC} = 5.0 V
I_{CC} Cusor [2,3]	I_{CC} (CU)	mA	147	140	125	110	105	V_{CC} = 5.0 V
I_{CC} Blank	I_{CC} (BL)	mA	1.85		1.5		1.15	V_{CC} = 5.0 V BL = 0.8 V
Input Current, Max.	I_{IL}	μA	20		17		14	V_{CC} = 5.0 V V_{IN} = 0.8 V

GUARANTEED VALUES

Parameter	Symbol	Units	25°C V_{CC} = 5.0 V	Maximum Over Operating Temperature Range V_{CC} = 5.5 V
I_{CC} 4 digits on (10 seg/digit) [1,2]	I_{CC}	mA	115	170
I_{CC} Cursor [2,3]	I_{CC} ($\overline{CU}$)	mA	165	232
I_{CC} Blank	I_{CC} ($\overline{BL}$)	mA	3.5	8.0
Input Current, Max.	I_{IL}	μA	30	40
Power Dissipation [4]	P_D	mW	575	910

Notes:
1. "%" illuminated in all four characters.
2. Measured at five seconds.
3. Cursor character is sixteen segments and DP on.
4. Power dissipation = $V_{CC} \cdot I_{CC}$ (10 seg.).

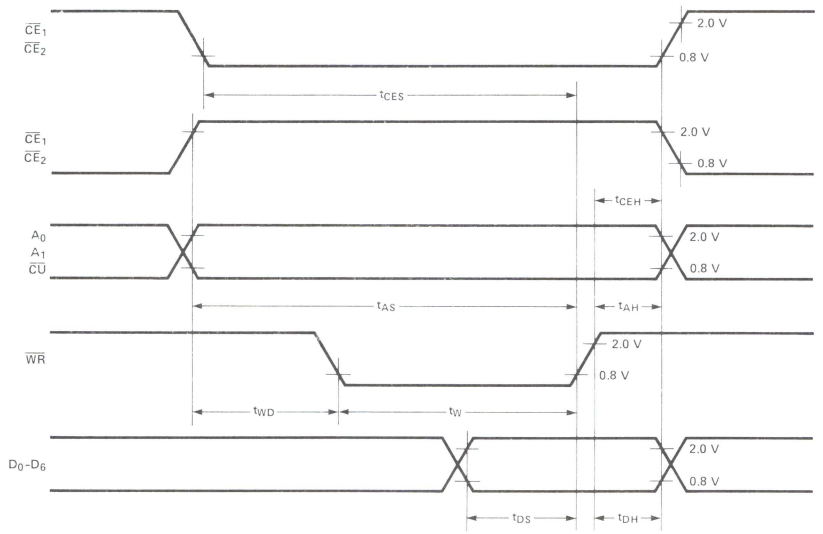
AC Timing Characteristics Over Operating Temperature Range at V_{CC} = 4.5 V

Parameter	Symbol	-20°C t_{MIN}	25°C t_{MIN}	70°C t_{MIN}	Units
Address Setup Time	t_{AS}	90	115	150	ns
Write Delay Time	t_{WD}	10	15	20	ns
Write Time	t_W	80	100	130	ns
Data Setup Time	t_{DS}	40	60	80	ns
Data Hold Time	t_{DH}	40	45	50	ns
Address Hold Time	t_{AH}	40	45	50	ns
Chip Enable Hold Time	t_{CEH}	40	45	50	ns
Chip Enable Setup Time	t_{CES}	90	115	150	ns
Clear Time	t_{CLR}	2.4	3.5	4.0	ms
Access Time		130	160	200	ns
Refresh Rate		420-790	310-630	270-550	Hz

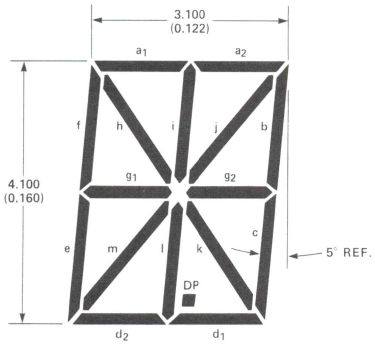
Optical Characteristics

Parameter	Symbol	Test Condition	Min.	Typ.	Units
Peak Luminous Intensity per digit, 8 segments on (character average)	I_V Peak	V_{CC} = 5.0 V "✳" illuminated in all 4 digits.	0.5	1.25	mcd
Peak Wavelength	λpeak			655	nm
Dominant Wavelength	λ_d			640	nm
Off Axis Viewing Angle				±50	degrees
Digit Size				4.1	mm

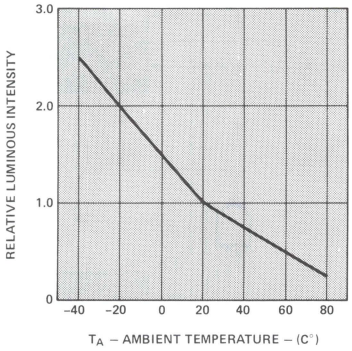
Timing Diagram



Magnified Character Font Description



Relative Luminous Intensity vs. Temperature



Electrical Description

Display Internal Block Diagram

Figure 1 shows the internal block diagram for the HPDL-2416 display. The CMOS IC consists of a four-word ASCII memory, a four-word cursor memory, a 64-word character generator, 17 segment drivers, four digit drivers, and the scanning circuitry necessary to multiplex the four monolithic LED characters. In normal operation, the divide-by-four counter sequentially accesses each of the four RAM locations and simultaneously enables the appropriate display digit driver. The output of the RAM is decoded by the character generator which, in turn, enables the appropriate display segment drivers. For each display location, the cursor enable (CUE) selects whether the data from the ASCII RAM (CUE = 0) or the stored cursor (CUE = 1) is to be displayed. The cursor character is denoted by all sixteen segments and the DP ON. Seven-bit ASCII data is stored in RAM. Since the display utilizes a 64-character decoder, half of the possible 128 input combinations are invalid. For each display location where $D_5 = D_6$ in the ASCII RAM, the display character is blanked. The entire display is blanked when $\overline{BL} = 0$.

Data is loaded into the display through the data inputs (D_6-D_0), address inputs (A_1, A_0), chip enables ($\overline{CE}_1$, $\overline{CE}_2$), cursor select ($\overline{CU}$), and write ($\overline{WR}$). The cursor select ($\overline{CU}$) determines whether data is stored in the ASCII RAM ($\overline{CU}$ = 1) or cursor memory ($\overline{CU} = 0$). When $\overline{CE}_1 = \overline{CE}_2 = \overline{WR} = 0$ and $\overline{CU} = 1$, the information on the data inputs is stored in the ASCII RAM at the location specified by the address inputs (A_1, A_0). When $\overline{CE}_1 = \overline{CE}_2 = \overline{WR} = 0$ and $\overline{CU} = 0$, information on the data input, D_0, is stored in the cursor at the location specified by the address inputs (A_1, A_0). If $D_0 = 1$, a cursor character is stored in the cursor memory. If $D_0 = 0$, a previously stored cursor character will be removed from the cursor memory.

If the clear input ($\overline{CLR}$) equals zero for one internal display cycle (4 ms minimum), the data in the ASCII RAM will be rewritten with zeroes and the display will be blanked. Note that the blanking input ($\overline{BL}$) must be equal to logical one during this time.

Data Entry

Figure 2 shows a truth table for the HPDL-2416 display. Setting the chip enables ($\overline{CE}_1$, $\overline{CE}_2$) to their low state and the cursor select ($\overline{CU}$) to its high state will enable data loading. The desired data inputs (D_6-D_0) and address inputs (A_1, A_0) as well as the chip enables ($\overline{CE}_1$, $\overline{CE}_2$) and cursor select ($\overline{CU}$) must be held stable during the write cycle to ensure that the correct data is stored into the display. Valid ASCII data codes are shown in Figure 3. The display accepts standard seven-bit ASCII data. Note that $D_6 = D_5$ for the codes shown in Figure 2. If $D_6 = D_5$ during the write cycle, then a blank will be stored in the display. Data can be loaded into the display in any order. Note that when $A_1 = A_0 = 0$, data is stored in the furthest right-hand display location.

Cursor Entry

As shown in Figure 2, setting the chip enables ($\overline{CE}_1$, $\overline{CE}_2$) to their low state and the cursor select ($\overline{CU}$) to its low state will enable cursor loading. The cursor character is indicated by the display symbol having all 16 segments and the DP ON. The least significant data input (D_0), the address inputs (A_1, A_0), the chip enables ($\overline{CE}_1$, $\overline{CE}_2$), and the cursor select ($\overline{CU}$) must be held stable during the write cycle to ensure that the correct data is stored in the display. If D_0 is in a low state during the write cycle, then a cursor character will be removed at the indicated location. If D_0 is in a high state euring the write cycle, then a cursor character will be stored at the indicated location. The presence or absence of a cursor character does not affect the ASCII data stored at that location. Again, when $A_1 = A_0 = 0$, the cursor character is stored in the furthest right-hand display location.

All stored cursor characters are displayed if the cursor enable (CUE) is high. Similarly, the stored ASCII data words are displayed, regardless of the cursor characters, if the cursor enable (CUE) is low. The cursor enable (CUE) has no effect on the storage or removal of the cursor characters within the display. A flashing cursor is displayed by pulsing the cursor enable (CUE). For applications not requiring a cursor, the cursor enable (CUE) can be connected to ground and the cursor select ($\overline{CU}$) can be connected to V_{CC}. This inhibits the cursor function and allows only ASCII data to be loaded into the display.

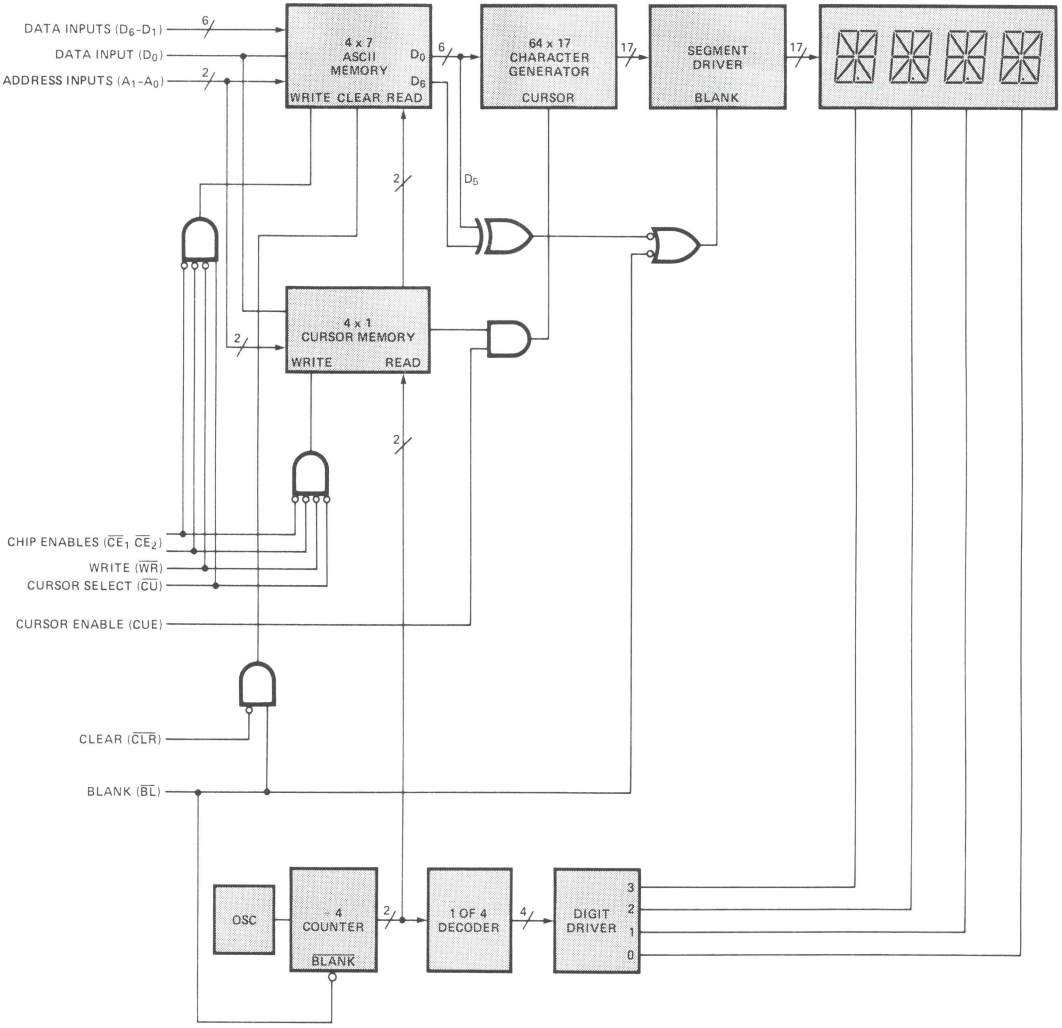


Figure 1. HPDL-2416 Internal Block Diagram

Display Clear

As shown in Figure 2, the ASCII data stored in the display will be cleared if the clear ($\overline{CLR}$) is held low and the blanking input ($\overline{BL}$) is held high for 4 ms minimum. The cursor memory is not affected by the clear ($\overline{CLR}$) input. Cursor characters can be stored or removed even while the clear ($\overline{CLR}$) is low. Note that the display will be cleared regardless of the state of the chip enables ($\overline{CE_1}$, $\overline{CE_2}$). However, to ensure that all four display characters are cleared, $\overline{CLR}$ should be held low for 4 ms following the last write cycle.

Display Blank

As shown in Figure 2, the display will be blanked if the blanking input ($\overline{BL}$) is held low. Note that the display will be blanked regardless of the state of the chip enables ($\overline{CE_1}$, $\overline{CE_2}$) or write ($\overline{WR}$) inputs. The ASCII data stored in the display and the cursor memory are not affected by the blanking input. ASCII data and cursor data can be stored even while the blanking input ($\overline{BL}$) is low. Note that while the blanking input ($\overline{BL}$) is low, the clear ($\overline{CLR}$) function is inhibited. A flashing display can be obtained by applying a low frequency square wave to the blanking input ($\overline{BL}$). Because the blanking input ($\overline{BL}$) also resets the internal display multiplex counter, the frequency applied to the blanking input ($\overline{BL}$) should be much slower than the display multiplex rate. Finally, dimming of the display through the blanking input ($\overline{BL}$) is not recommended.

For further application information please consult Application Note 1026.

Function	$\overline{BL}$	$\overline{CLR}$	CUE	$\overline{CU}$	$\overline{CE_1}$	$\overline{CE_2}$	$\overline{WR}$	A_1	A_0	D_6	D_5	D_4	D_3	D_2	D_1	D_0	DIG_3	DIG_2	DIG_1	DIG_0
Write Data Memory	L	X	X	H	L	L	L	L	L	a	a	a	a	a	a	a	NC	NC	NC	A
				-OR-				L	H	b	b	b	b	b	b	b	NC	NC	B	NC
	X	H	X	H	L	L	L	H	L	c	c	c	c	c	c	c	NC	C	NC	NC
								H	H	d	d	d	d	d	d	d	D	NC	NC	NC
Disable Data Memory Write	X	X	X	H	X	X	H	X	X	X	X	X	X	X	X	X	Previously Written Data			
	X	X	X	H	X	H	X													
	X	X	X	H	H	X	X													
Write Cursor	X	X	X	L	L	L	L	L	L	X	X	X	X	X	X	H	NC	NC	NC	⊠
								L	H	X	X	X	X	X	X	H	NC	NC	⊠	NC
								H	L	X	X	X	X	X	X	H	NC	⊠	NC	NC
								H	H	X	X	X	X	X	X	H	⊠	NC	NC	NC
Clear Cursor	X	X	X	L	L	L	L	L	L	X	X	X	X	X	X	L	NC	NC	NC	⬚
								L	H	X	X	X	X	X	X	L	NC	NC	⬚	NC
								H	L	X	X	X	X	X	X	L	NC	⬚	NC	NC
								H	H	X	X	X	X	X	X	L	⬚	NC	NC	NC
Disable Cursor Memory	X	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	Previously Written Cursor			
	X	X	X	L	X	H	X													
	X	X	X	L	H	X	X													

L = LOGIC LOW INPUT
H = LOGIC HIGH INPUT
X = DON'T CARE
"a" = ASCII CODE CORRESPONDING TO SYMBOL "A"
NC = NO CHANGE
⊠ = CURSOR CHARACTER (ALL SEGMENTS ON)

Figure 2a. Cursor/Data Memory Write Truth Table

Function	$\overline{BL}$	$\overline{CLR}$	CUE	$\overline{CU}$	$\overline{CE_1}$	$\overline{CE_2}$	$\overline{WR}$	DIG_3	DIG_2	DIG_1	DIG_0	
CUE	H	H	L	X	X	X	X	A	B	C	D	Display previously written data
	H	H	H	X	X	X	X	⊠	⊠	⊠	⊠	Display previously written cursor
Clear	H	L	X	X	X	X	X*	⬚	⬚	⬚	⬚	Clear data memory, cursor memory unchanged
	*NOTE: CLR should be held low for 4 ms following the last WRITE cycle to ensure all data is cleared.											
Blanking	L	X	X	X	X	X	X	⬚	⬚	⬚	⬚	Blank display, data and cursor memories unchanged.

Figure 2b. Displayed Data Truth Table

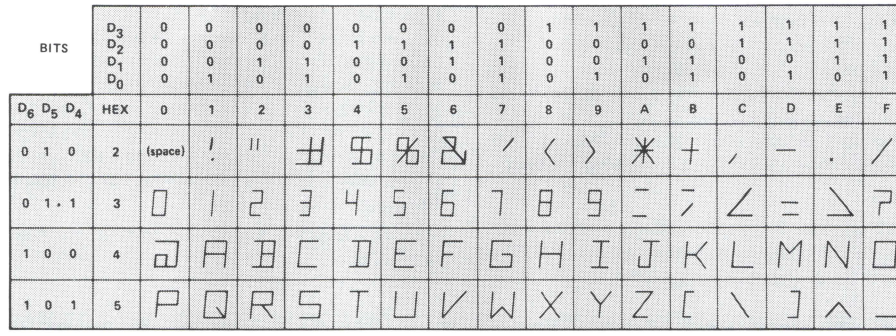


Figure 3. HPDL-2416 ASCII Character Set

Mechanical and Electrical Considerations

The HPDL-2416 is an 18 pin dual-in-line package that can be stacked horizontally and vertically to create arrays of any size. This display is designed to operate continuously between -40° C to +85° C with a maximum of 10 segments on per digit.

During continuous operation of all four Cursors the operating temperature should be limited to -40° C to +55° C. At temperatures above +55° C, the maximum number of Cursors illuminated continuously should be reduced as follows: No Cursors illuminated at operating temperatures above 75° C. One Cursor can be illuminated continuously at operating temperatures below 75° C. Two Cursors can be illuminated continuously at operating temperatures below 68° C. Three Cursors can be illuminated continuously at operating temperatures below 60° C.

The HPDL-2416 is assembled by die attaching and wire bonding the four GaAsP/GaAs monolithic LED chips and the CMOS IC to a high temperature printed circuit board. An immersion lens is formed by placing the PC board assembly into a nylon lens filled with epoxy. A plastic cap creates an air gap to protect the CMOS IC. Backfill epoxy environmentally seals the display package. This package construction provides the display with a high tolerance to temperature cycling.

The inputs to the CMOS IC are protected against static discharge and input current latchup. However, for best results standard CMOS handling precautions should be used. Prior to use, the HPDL-2416 should be stored in antistatic tubes or conductive material. During assembly a grounded conductive work area should be used, and assembly personnel should wear conductive wrist straps. Lab coats made of synthetic material should be avoided since they are prone to static charge build-up. Input current latchup is caused when the CMOS inputs are subjected either to a voltage below ground (V_{IN} < ground) or to a voltage higher than V_{CC} (V_{IN} > V_{CC}) and when a high current is forced into the input. To prevent input current latchup and ESD damage, unused inputs should be connected either to ground or to V_{CC}. Voltages should not be applied to the inputs until V_{CC} has been applied to the display. Transient input voltages should be eliminated.

Soldering and Post Solder Cleaning Instructions for the HPDL-2416

The HPDL-2416 may be hand soldered or wave soldered with SN63 solder. Hand soldering may be safely performed only with an electronically temperature-controlled and securely grounded soldering iron. For best results, the iron tip temperature should be set at 315° C (600° F). For wave soldering, a rosin-based RMA flux can be used. The solder wave temperature should be 245° C ±5° C (473° F ±9° F), and the dwell in the wave should be set at 1½ to 3 seconds for optimum soldering. Preheat temperature should not exceed 93° C (200° F) as measured on the solder side of the PC board.

Post solder cleaning may be performed with a solvent or aqueous process. For solvent cleaning, Allied Chemical Genesolv DES, Baron Blakeslee Blaco-Tron TES or DuPont Freon TE can only be used. These solvents are azeotropes of trichlorotrifluoroethane FC-113 with low concentrations of ethanol (5%). The maximum exposure time in the solvent vapors at boiling temperature should not exceed 2 minutes. Solvents containing high concentrations of alcohols, pure alcohols, isopropanol or acetone should not be used as they will chemically attack the nylons lens. Solvents containing trichloroethane FC-111 or FC-112 and trichloroethylene (TCE) are not recommended.

An aqueous cleaning process is highly recommended. A saponifier, such as Kester-Bio-kleen Formula 5799 or equivalent, may be added to the wash cycle of an aqueous process to remove rosin flux residues. Organic acid flux residues must be thoroughly removed by an aqueous cleaning process to prevent corrosion of the leads and solder connections. The optimum water temperature is 60°C (140°F). The maximum cumulative exposure of the HPDL-2416 to wash and rinse cycles should not exceed 15 minutes.

Optical Considerations/ Contrast Enhancement

The HPDL-2416 display uses a precision aspheric immersion lens to provide excellent readability and low off-axis distortion. The aspheric lens produces a magnified character height of 4.1 mm (0.160 in.) and a viewing angle of ±50°. These features provide excellent readability at distances up to 2 metres (6 feet).

Each HPDL-2416 display is tested for luminous intensity and marked with an intensity category on the side of the display package. To ensure intensity matching for multiple package applications, mixing intensity categories for a given panel is not recommended.

The HPDL-2416 display is designed to provide maximum contrast when placed behind an appropriate contrast enhancement filter. Some suggested filters are Panelgraphic Ruby Red 60, Panelgraphic Dark Red 63, SGL Homalite H100-1650, Rohm and Haas 2423, Chequers Engraving 118, and 3M R6510. For further information on contrast enhancement, see Hewlett-Packard Application Note 1015.

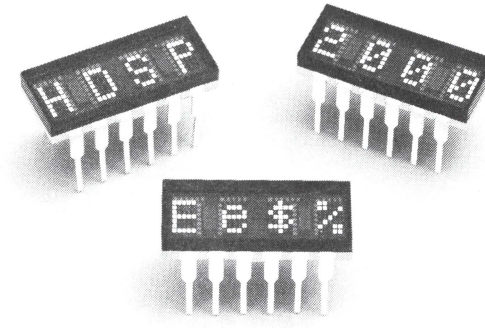
HEWLETT PACKARD

FOUR CHARACTER 3.8 mm (0.15 INCH) 5x7 ALPHANUMERIC DISPLAYS

STANDARD RED	HDSP-2000
YELLOW	HDSP-2001
HIGH EFFICIENCY RED	HDSP-2002
HIGH PERFORMANCE GREEN	HDSP-2003

Features

- **FOUR COLORS**
  Standard Red
  Yellow
  High Efficiency Red
  High Performance Green
- **INTEGRATED SHIFT REGISTERS WITH CONSTANT CURRENT DRIVERS**
- **COMPACT CERAMIC PACKAGE**
- **WIDE VIEWING ANGLE**
- **END STACKABLE FOUR CHARACTER PACKAGE**
- **TTL COMPATIBLE**
- **5 x 7 LED MATRIX DISPLAYS FULL ASCII SET**
- **CATEGORIZED FOR LUMINOUS INTENSITY**
- **HDSP-2001/2003 CATEGORIZED FOR COLOR**



Typical Applications

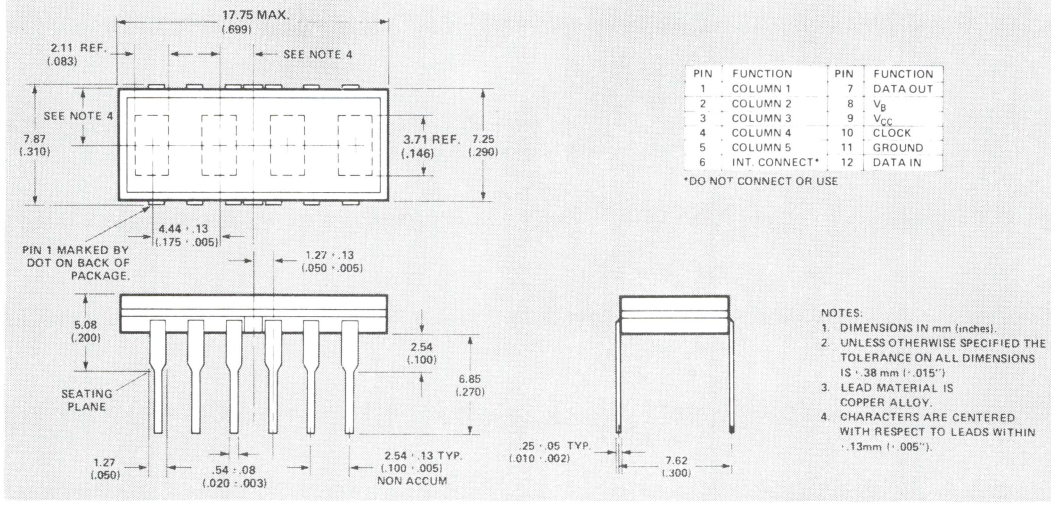
- **INDUSTRIAL PROCESS CONTROL EQUIPMENT**
- **BUSINESS MACHINES**
- **PROGRAMMABLE LEGEND SWITCHES**
- **MEDICAL INSTRUMENTS**
- **MILITARY GROUND SUPPORT EQUIPMENT**
- **COMPUTER PERIPHERALS**

Description

The HDSP-2000/-2001/-2002/-2003 series of displays are 3.8 mm (0.15 inch) 5 x 7 LED arrays for display of alphanumeric information. These devices are available in standard red, yellow, high efficiency red, and high performance green.

Each four character cluster is contained in a 12 pin dual-in-line package. An on-board SIPO (Serial-In-Parallel-Out) 7-bit shift register associated with each digit controls constant current LED row drivers. Full character display is achieved by external column strobing.

Package Dimensions



PIN	FUNCTION	PIN	FUNCTION
1	COLUMN 1	7	DATA OUT
2	COLUMN 2	8	V_B
3	COLUMN 3	9	V_{CC}
4	COLUMN 4	10	CLOCK
5	COLUMN 5	11	GROUND
6	INT. CONNECT*	12	DATA IN

*DO NOT CONNECT OR USE

NOTES:
1. DIMENSIONS IN mm (inches).
2. UNLESS OTHERWISE SPECIFIED THE TOLERANCE ON ALL DIMENSIONS IS ± .38 mm (± .015").
3. LEAD MATERIAL IS COPPER ALLOY.
4. CHARACTERS ARE CENTERED WITH RESPECT TO LEADS WITHIN ± .13mm (± .005").

Absolute Maximum Ratings (HDSP-2000/-2001/-2002/-2003)

Supply Voltage V_{CC} to Ground ..... —0.5V to 6.0V
Inputs, Data Out and V_B ..... —0.5V to V_{CC}
Column Input Voltage, V_{COL} ..... —0.5V to +6.0V
Free Air Operating
Temperature Range, T_A[1,2] ..... —20°C to +85°C
Storage Temperature Range, T_S ..... —55°C to +100°C
Maximum Allowable Power Dissipation
at T_A = 25°C[1,2,3] ..... 1.24 Watts
Maximum Solder Temperature 1.59 mm (0.063 in)
Below Seating Plane t < 5 sec ..... 260°C

Recommended Operating Conditions (HDSP-2000/-2001/-2002/-2003)

Parameter	Symbol	Min.	Nom.	Max.	Units	Fig.
Supply Voltage	V_{CC}	4.75	5.0	5.25	V	
Data Out Current, Low State	I_{OL}			1.6	mA	
Data Out Current, High State	I_{OH}			-0.5	mA	
Column Input Voltage, Column On HDSP-2000	V_{COL}	2.4		3.5	V	4
Column Input Voltage, Column On, HDSP-2001/-2002/-2003	V_{COL}	2.75		3.5	V	4
Setup Time	t_{setup}	70	45		ns	1
Hold Time	t_{hold}	30	0		ns	1
Width of Clock	$t_{w(Clock)}$	75			ns	1
Clock Frequency	f_{clock}	0		3	MHz	1
Clock Transition Time	t_{THL}			200	ns	1
Free Air Operating Temperature Range[1,2]	T_A	-20		85	°C	2

Electrical Characteristics Over Operating Temperature Range

(Unless otherwise specified)

Description		Symbol	Test Conditions		Min.	Typ.*	Max.	Units	Fig.
Supply Current		I_{CC}	V_{CC} = 5.25V, V_{CLOCK} = V_{DATA} = 2.4V, All SR Stages = Logical 1	V_B = 0.4V		45	60	mA	
				V_B = 2.4V		73	95	mA	
Column Current at any Column Input		I_{COL}	V_{CC} = 5.25 V, V_{COL} = 3.5V	V_B = 0.4V			500	μA	4
Column Current at any Column Input		I_{COL}	All SR Stages = Logical 1	V_B = 2.4V		335	410	mA	
V_B, Clock or Data Input Threshold High		V_{IH}	V_{CC} = V_{COL} = 4.75V		2.0			V	
V_B, Clock or Data Input Threshold Low		V_{IL}					0.8	V	
Input Current Logical 1	V_B, Clock	I_{IH}	V_{CC} = 5.25V, V_{IH} = 2.4V			20	80	μA	
	Data In	I_{IH}				10	40	μA	
Input Current Logical 0	V_B, Clock	I_{IL}	V_{CC} = 5.25V, V_{IL} = 0.4V			-500	-800	μA	
	Data In	I_{IL}				-250	-400	μA	
Data Out Voltage		V_{OH}	V_{CC} = 4.75V, I_{OH} = -0.5 mA, I_{COL} = 0 mA		2.4	3.4		V	
		V_{OL}	V_{CC} = 4.75V, I_{OL} = 1.6 mA, I_{COL} = 0 mA			0.2	0.4	V	
Power Dissipation Per Package**		P_D	V_{CC} = 5.0V, V_{COL} = 3.5V, 17.5% DF, 15 LEDs on per character, V_B = 2.4V			0.72		W	2
Thermal Resistance IC Junction-to-Case		$R\theta_{J-C}$				25		°C/W/ Device	2

*All typical values specified at V_{CC} = 5.0V and T_A = 25°C unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

1. Operation above 85°C ambient is possible provided the following conditions are met. The junction should not exceed 125°C T_J and the case temperature (as measured at pin 1 or the back of the display) should not exceed 100°C T_C.
2. The device should be derated linearly above 50°C at 16.7 mW/°C. This derating is based on a device mounted in a socket having a thermal resistance from case to ambient at 35°C/W per device. See Figure 2 for power deratings based on a lower thermal resistance.
3. Maximum allowable dissipation is derived from V_{CC} = 5.25V, V_B = 2.4V, V_{COL} = 3.5V 20 LEDs on per character, 20% DF.

Optical Characteristics

STANDARD RED HDSP-2000

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	105	200		µcd	3
Peak Wavelength	λ_{PEAK}			655		nm	
Dominant Wavelength[7]	λ_d			639		nm	

YELLOW HDSP-2001

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	400	750		µcd	3
Peak Wavelength	λ_{PEAK}			583		nm	
Dominant Wavelength[5,7]	λ_d			585		nm	

HIGH EFFICIENCY RED HDSP-2002

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	400	1430		µcd	3
Peak Wavelength	λ_{PEAK}			635		nm	
Dominant Wavelength[7]	λ_d			626		nm	

HIGH PERFORMANCE GREEN HDSP-2003

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	850	1550		µcd	3
Peak Wavelength	λ_{PEAK}			568		nm	
Dominant Wavelength[5,7]	λ_d			574		nm	

*All typical values specified at V_{CC} = 5.0V and T_A = 25°C unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

4. The characters are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
5. The HDSP-2001/-2003 are categorized for color with the color category designated by a number code on the bottom of the package.
6. T_j refers to the initial case temperature of the device immediately prior to the light measurement.
7. Dominant wavelength λ_d, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
8. The luminous sterance of the LED may be calculated using the following relationships:
   L_V (cd/m²) = I_V (Candela)/A (Metre)²
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)²
   A = 5.3 x 10^{-8} M² = 5.8 x 10^{-7} (Foot)²

Electrical Description

The HDSP-200X series of four character alphanumeric displays have been designed to allow the user maximum flexibility in interface electronics design. Each four character display module features DATA IN and DATA OUT terminals arrayed for easy PC board interconnection. DATA OUT represents the output of the 7th bit of digit number 4 shift register. Shift register clocking occurs on the high to low transition of the clock input. The like columns of each character in a display cluster are tied to a single pin. Figure 5 is the block diagram for the displays. High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5 x 7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduction in power consumption.

In the normal mode of operation, input data for digit 4 column 1 is loaded into the 7 on-board shift register locations 1 through 7. Column 1 data for digits 3, 2 and 1 is similarly shifted into the display shift register locations. The column 1 input is now enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4 and 5. If the time necessary to decode and load data into the shift register is t, then with 5 columns, each column of the display is operating at a duty factor of:

$$D.F. = \frac{T}{5(t+T)}$$

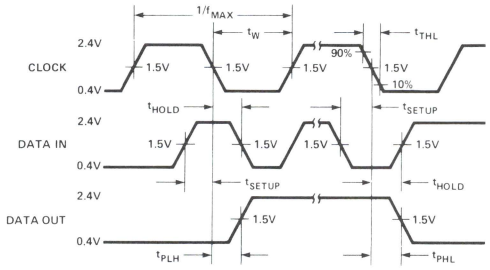
The time frame, t + T, alloted to each column of the display is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time t + T of:

$$1/(5 \times (100)) = 2 \text{ msec}$$

If the device is operated at 3.0 MHz clock rate maximum, it is possible to maintain t << T. For short display strings, the duty factor will then approach 20%.

For further applications information, refer to HP Application Note 1016.



Parameter	Condition	Min.	Typ.	Max.	Units
f_{clock} CLOCK Rate				3	MHz
t_{PLH}, t_{PHL} Propagation delay CLOCK to DATA OUT	C_L = 15pF R_L=2.4KΩ			125	ns

Figure 1. Switching Characteristics HDSP-2000/-2001/-2002/-2003 (T_A = -20° C to +85° C)

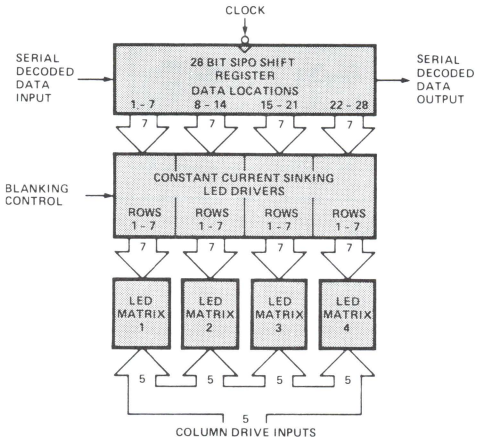


Figure 5. Block Diagram of HDSP-2000/-2001/-2002/-2003

Mechanical and Thermal Considerations

The HDSP-2000/-2001/-2002/-2003 are available in standard ceramic dual-in-line packages. They are designed for plugging into sockets or soldering into PC boards. The packages may be horizontally or vertically stacked for character arrays of any desired size. Full power operation (V_{CC} = 5.25V, V_B = 2.4V, V_{COL} = 3.5V) with worst case thermal resistance from IC junction to ambient of 60° C/wat-t/device is possible up to ambient temperature of 50° C. For operation above 50° C, the maximum device dissipation should be derated linearly at 16.7 mW/° C (see Figure 2). With an improved thermal design, operation at higher ambient temperatures without derating is possible.

Power derating for this family of displays can be achieved in several ways. The power supply voltage can be lowered to a minimum of 4.75V. Column Input Voltage, V_{COL}, can be decreased to the recommended minimum values of 2.4V for the HDSP-2000 and 2.75V for the HDSP-2001/-2002/-2003. Also, the average drive current can be decreased through pulse width modulation of V_B. Please refer to HP Application Note 1016 for further information.

The HDSP-2000/-2001/-2002/-2003 displays have glass windows. A front panel contrast enhancement filter is desirable in most actual display applications. Some suggested filter materials are provided in Figure 6. Additional information on filtering and constrast enhancement can be found in HP Application Note 1015.

Post solder cleaning may be accomplished using water or Freon/alcohol mixtures formulated for vapor cleaning processing or Freon/alcohol mixtures formulated for room temperature cleaning. Freon/alcohol vapor cleaning processing for up to 2 minutes in vapors at boiling is permissible. Suggested solvents include Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15, and water.

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
HDSP-2000 Std. Red	Panelgraphic Dark Red 63 Ruby Red 60 Chequers Red 118 Plexiglass 2423		
HDSP-2001 (Yellow)	Panelgraphic Yellow 27 Chequers Amber 107	Polaroid HNCP37 3M Light Control Film Panelgraphic Gray 10	Polaroid HNCP10-Glass Marks Polarized MPC-0301-8-10
HDSP-2002 (HER)	Panelgraphic Ruby Red 60 Chequers Red 112	Chequers Grey 105	Note 1 Polaroid HNCP10-Glass Marks Polarized MPC-0201-2-22
HDSP-2003 (HP Green)	Panelgraphic Green 48 Chequers Green 107		Polaroid HNCP10-Glass Marks Polarized MPC-0101-5-12

Note: 1. Optically coated circular polarized filters, such as Polaroid HNCP10.

Figure 6. Contrast Enhancement Filters

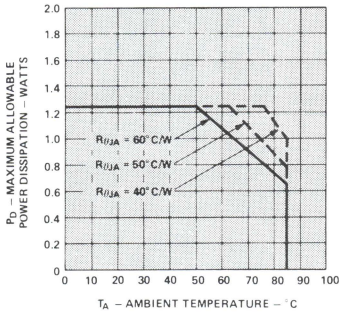


Figure 2. Maximum Allowable Power Dissipation vs. Temperature

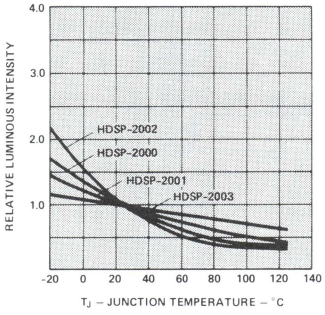


Figure 3. Relative Luminous Intensity vs. Temperature

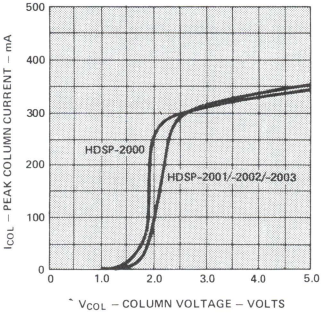


Figure 4. Peak Column Current vs. Column Voltage

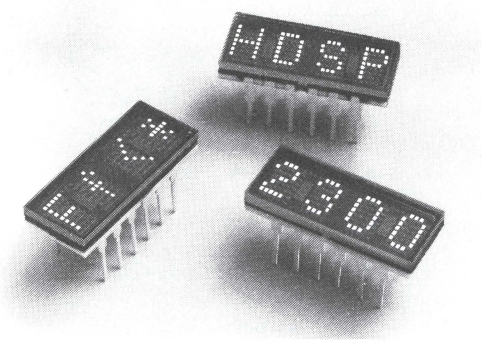
HEWLETT PACKARD

FOUR CHARACTER 5.0 mm (0.20 INCH) 5x7 ALPHANUMERIC DISPLAYS

STANDARD RED	HDSP-2300
YELLOW	HDSP-2301
HIGH EFFICIENCY RED	HDSP-2302
HIGH PERFORMANCE GREEN	HDSP-2303

Features

- FOUR COLORS
  - Standard Red
  - Yellow
  - High Efficiency Red
  - High Performance Green
- INTEGRATED SHIFT REGISTERS WITH CONSTANT CURRENT DRIVERS
- COMPACT CERAMIC PACKAGE
- WIDE VIEWING ANGLE
- END STACKABLE FOUR CHARACTER PACKAGE
- TTL COMPATIBLE
- 5 x 7 LED MATRIX DISPLAYS FULL ASCII SET
- CATEGORIZED FOR LUMINOUS INTENSITY
- HDSP-2301/2303 CATEGORIZED FOR COLOR



Typical Applications

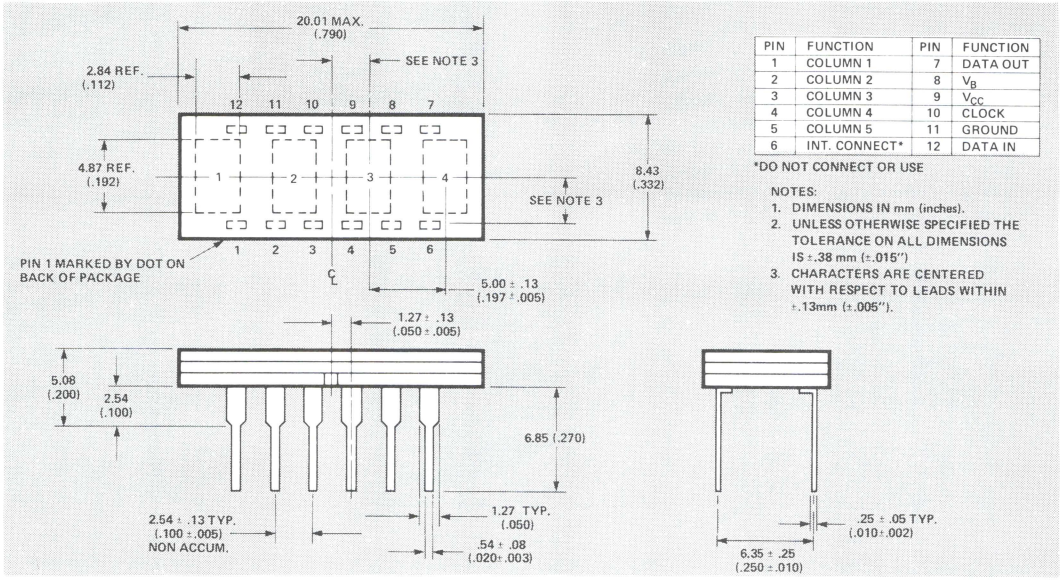
- AVIONICS
- BUSINESS MACHINES
- MEDICAL INSTRUMENTS
- INDUSTRIAL PROCESS CONTROL EQUIPMENT
- COMPUTER PERPHERALS

Description

The HDSP-2300/-2301/-2302/-2303 series of displays are 5.0 mm (0.20 inch) 5 x 7 LED arrays for display of alphanumeric information. These devices are available in standard red, yellow, high efficiency red, and high performance green.

Each four character cluster is contained in a 12 pin dual-in-line package. An on-board SIPO (Serial-In-Parallel-Out) 7-bit shift register associated with each digit controls constant current LED row drivers. Full character display is achieved by external column strobing.

Package Dimensions



PIN	FUNCTION	PIN	FUNCTION
1	COLUMN 1	7	DATA OUT
2	COLUMN 2	8	V_B
3	COLUMN 3	9	V_{CC}
4	COLUMN 4	10	CLOCK
5	COLUMN 5	11	GROUND
6	INT. CONNECT*	12	DATA IN

*DO NOT CONNECT OR USE

NOTES:
1. DIMENSIONS IN mm (inches).
2. UNLESS OTHERWISE SPECIFIED THE TOLERANCE ON ALL DIMENSIONS IS ±.38 mm (±.015").
3. CHARACTERS ARE CENTERED WITH RESPECT TO LEADS WITHIN ±.13mm (±.005").

Absolute Maximum Ratings (HDSP-2300/-2301/-2302/-2303)

Supply Voltage V_{CC} to Ground ..... —0.5V to 6.0V
Inputs, Data Out and V_B ..... —0.5V to V_{CC}
Column Input Voltage, V_{COL} ..... —0.5V to +6.0V
Free Air Operating
Temperature Range, T_A[1,2] ..... —20°C to +85°C
Storage Temperature Range, T_S ..... —55°C to +100°C

Maximum Allowable Power Dissipation
at $T_A = 25°C$ [1,2,3]
HDSP-2300 ..... 1.24 Watts
HDSP-2301/-2302/-2303 ..... 1.46 Watts
Maximum Solder Temperature is 1.59 mm (0.063 in)
Below Seating Plane t < 5 sec ..... 260°C

Recommended Operating Conditions (HDSP-2300/-2301/-2302/-2303)

Parameter	Symbol	Min.	Nom.	Max.	Units	Fig.
Supply Voltage	V_{CC}	4.75	5.0	5.25	V	
Data Out Current, Low State	I_{OL}			1.6	mA	
Data Out Current, High State	I_{OH}			-0.5	mA	
Column Input Voltage, Column On HDSP-2300	V_{COL}	2.4		3.5	V	4
Column Input Voltage, Column On HDSP-2301/-2302/-2303	V_{COL}	2.75		3.5	V	7
Setup Time	t_{setup}	70	45		ns	1
Hold Time	t_{hold}	30	0		ns	1
Width of Clock	$t_{w(Clock)}$	75			ns	1
Clock Frequency	f_{clock}	0		3	MHz	1
Clock Transition Time	t_{THL}			200	ns	1
Free Air Operating Temperature Range[1,2]	T_A	-20		85	°C	3, 5

Electrical Characteristics Over Operating Temperature Range

(Unless otherwise specified)

STANDARD RED HDSP-2300

Description		Symbol	Test Conditions		Min.	Typ.*	Max.	Units	Fig.
Supply Current		I_{CC}	$V_{CC} = 5.25V$, $V_{CLOCK} = V_{DATA} = 2.4V$, All SR Stages = Logical 1	$V_B = 0.4V$		45	60	mA	
				$V_B = 2.4V$		73	95	mA	
Column Current at any Column Input		I_{COL}	$V_{CC} = 5.25$ V, $V_{COL} = 3.5V$	$V_B = 0.4V$			500	μA	4
Column Current at any Column Input		I_{COL}	All SR Stages = Logical 1	$V_B = 2.4V$		335	410	mA	
V_B, Clock or Data Input Threshold High		V_{IH}	$V_{CC} = V_{COL} = 4.75V$		2.0			V	
V_B, Clock or Data Input Threshold Low		V_{IL}					0.8	V	
Input Current Logical 1	V_B, Clock	I_{IH}	$V_{CC} = 5.25V$, $V_{IH} = 2.4V$			20	80	μA	
	Data In	I_{IH}				10	40	μA	
Input Current Logical 0	V_B, Clock	I_{IL}	$V_{CC} = 5.25V$, $V_{IL} = 0.4V$			-500	-800	μA	
	Data In	I_{IL}				-250	-400	μA	
Data Out Voltage		V_{OH}	$V_{CC} = 4.75V$, $I_{OH} = -0.5$ mA, $I_{COL} = 0$ mA		2.4	3.4		V	
		V_{OL}	$V_{CC} = 4.75V$, $I_{OL} = 1.6$ mA, $I_{COL} = 0$ mA			0.2	0.4	V	
Power Dissipation Per Package**		P_D	$V_{CC} = 5.0V$, $V_{COL} = 3.5V$, 17.5% DF, 15 LEDs on per character, $V_B = 2.4V$			0.72		W	2
Thermal Resistance IC Junction-to-Case		$R\theta_{J-C}$				25		°C/W/ Device	2

*All typical values specified at $V_{CC} = 5.0V$ and $T_A = 25°C$ unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

1. Operation above 85°C ambient is possible provided the following conditions are met. The junction temperature should not exceed 125°C T_J and the case temperature (as measureed at pin 1 or the back of the display) should not exceed 100°C T_C.
2. The HDSP-2300 should be derated linearly above 50°C at 16.7 mW/°C. The HDSP-2301/-2302/-2303 should be derated linearly above 37°C at 16.7 mW/°C. This derating is based on a device mounted in a socket having a thermal resistance from case to ambient at 35°** C/W per device. See Figure 2 for power deratings based on a lower thermal resistance.
3. Maximum allowable dissipation is derived from $V_{CC} = 5.25V$, $V_B = 2.4V$, $V_{COL} = 3.5V$ 20 LEDs on per character, 20% DF.

YELLOW HDSP-2301/HIGH EFFICIENCY RED HDSP-2302/HIGH PERFORMANCE GREEN HDSP-2303

Description		Symbol	Test Conditions		Min.	Typ.*	Max.	Units	Fig.
Supply Current		I_{CC}	V_{CC} = 5.25V, V_{CLOCK} = V_{DATA} = 2.4V, All SR Stages = Logical 1	V_B = 0.4V		45	60	mA	
				V_B = 2.4V		73	95	mA	
Column Current at any Column Input		I_{COL}	V_{CC} = 5.25 V, V_{COL} = 3.5V	V_B = 0.4V			500	µA	7
Column Current at any Column Input		I_{COL}	All SR Stages = Logical 1	V_B = 2.4V		380	520	mA	
V_B, Clock or Data Input Threshold High		V_{IH}	V_{CC} = V_{COL} = 4.75V		2.0			V	
V_B, Clock or Data Input Threshold Low		V_{IL}					0.8	V	
Input Current Logical 1	V_B, Clock	I_{IH}	V_{CC} = 5.25V, V_{IH} = 2.4V			20	80	µA	
	Data In	I_{IH}				10	40	µA	
Input Current Logical 0	V_B, Clock	I_{IL}	V_{CC} = 5.25V, V_{IL} = 0.4V			-500	-800	µA	
	Data In	I_{IL}				-250	-400	µA	
Data Out Voltage		V_{OH}	V_{CC} = 4.75V, I_{OH} = -0.5 mA, I_{COL} = 0 mA		2.4	3.4		V	
		V_{OL}	V_{CC} = 4.75V, I_{OL} = 1.6 mA, I_{COL} = 0 mA			0.2	0.4	V	
Power Dissipation Per Package**		P_D	V_{CC} = 5.0V, V_{COL} = 3.5V, 17.5% DF, 15 LEDs on per character, V_B = 2.4V			0.78		W	5
Thermal Resistance IC Junction-to-Case		$R\theta_{J-C}$				25		°C/W/ Device	5

Optical Characteristics

STANDARD RED HDSP-2300

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V, T_j = 25° C[6], V_B = 2.4V	130	300		µcd	3
Peak Wavelength	λ_{PEAK}			655		nm	
Dominant Wavelength[7]	λ_d			639		nm	

YELLOW HDSP-2301

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V, T_j = 25° C[6], V_B = 2.4V	650	1140		µcd	6
Peak Wavelength	λ_{PEAK}			583		nm	
Dominant Wavelength[5,7]	λ_d			585		nm	

HIGH EFFICIENCY RED HDSP-2302

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V, T_j = 25° C[6], V_B = 2.4V	650	1430		µcd	6
Peak Wavelength	λ_{PEAK}			635		nm	
Dominant Wavelength[7]	λ_d			626		nm	

HIGH PERFORMANCE GREEN HDSP-2303

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V, T_j = 25° C[6], V_B = 2.4V	1280	2410		µcd	6
Peak Wavelength	λ_{PEAK}			568		nm	
Dominant Wavelength[5,7]	λ_d			574		nm	

*All typical values specified at V_{CC} = 5.0V and T_A = 25° C unless otherwise noted.

**Power dissipation per package with four characters illuminated.

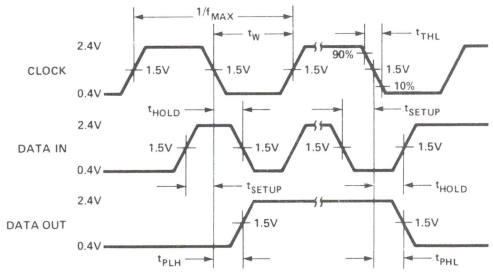
Notes:

4. The characters are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
5. The HDSP-2301/-2303 are categorized for color with the color category designated by a number code on the bottom of the package.
6. T_j refers to the initial case temperature of the device immediately prior to the light measurement.
7. Dominant wavelength λ_d, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
8. The luminous sterance of the LED may be calculated using the following relationships:

   L_v (cd/m²) = I_v (Candela)/A (Metre)²

   L_v (Footlamberts) = πI_V (Candela)/A (Foot)²

   A = 5.3 x 10^{-8} M² = 5.8 x 10^{-7} (Foot)²



Parameter	Condition	Min.	Typ.	Max.	Units
f_{clock} CLOCK Rate				3	MHz
t_{PLH}, t_{PHL} Propagation delay CLOCK to DATA OUT	C_L = 15pF R_L=2.4KΩ			125	ns

Figure 1. Switching Characteristics HDSP-2300/-2301/-2302/-2303 (T_A = -20° C to +85° C)

HDSP-2300

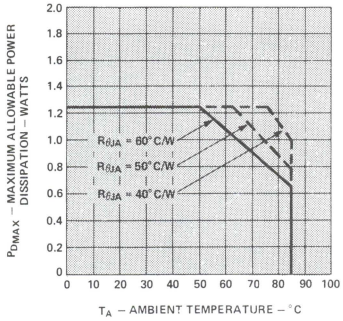


Figure 2. Maximum Allowable Power Dissipation vs. Temperature

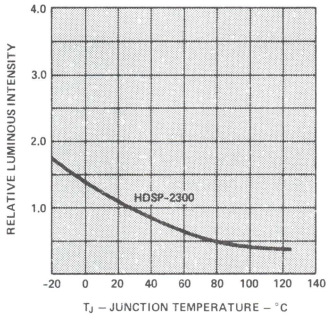


Figure 3. Relative Luminous Intensity vs. Temperature

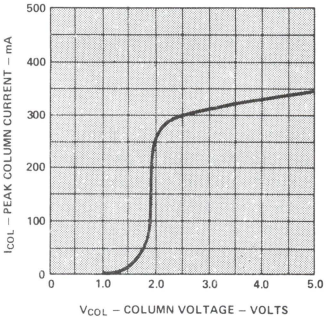


Figure 4. Peak Column Current vs. Column Voltage

HDSP-2301/-2302/-2303

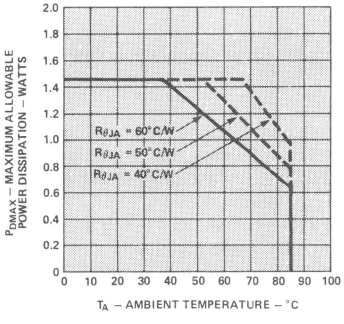


Figure 5. Maximum Allowable Power Dissipation vs. Temperature

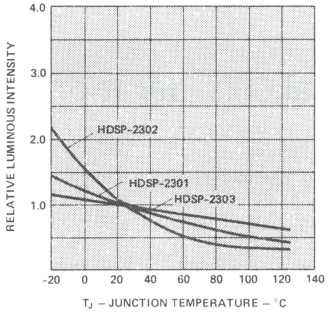


Figure 6. Relative Luminous Intensity vs. Temperature

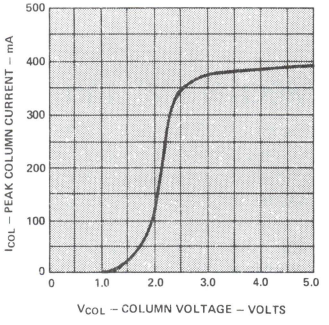


Figure 7. Peak Column Current vs. Column Voltage

Electrical Description

The HDSP-230X series of four character alphanumeric displays have been designed to allow the user maximum flexibility in interface electonics design. Each four character display module features DATA IN and DATA OUT terminals arrayed for easy PC board interconnection. DATA OUT represents the output of the 7th bit of digit number 4 shift register. Shift register clocking occurs on the high to low transition of the Clock input. The like columns of each character in a display cluster are tied to a single pin. Figure 5 is the block diagram for the displays. High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5 x 7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduction in power consumption.

In the normal mode of operation, input data for digit 4 column 1 is loaded into the 7 on-board shift register locations 1 through 7. Column data for digits 3, 2, and 1 is similiarly shifted into the display shift register locations. The column 1 input is now enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4 and 5. If the time necessary to decode the load data into the shift register is t, then with 5 columns, each column of the display is operating at a duty factor of:

$$D.F. = \frac{T}{5\,(t+T)}$$

The time frame, t + T, alloted to each column of the display is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time t + T of:

$$1/[5 \times (100)] = 2 \text{ msec}$$

If the device is operated at 3.0 MHz clock rate maximum, it is possible to maintain $t << T$. For short display strings, the duty factor will then approach 20%.

For further applications information, refer to HP Application Note 1016.

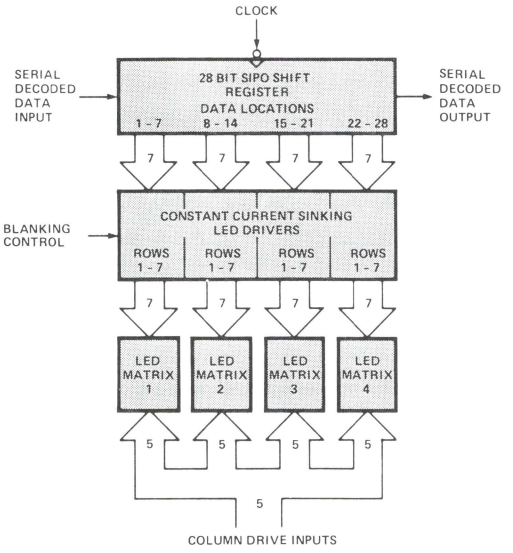


Figure 8. Block Diagram of HDSP-2300/-2301/-2302/-2303

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
HDSP-2000 Std. Red	Panelgraphic Dark Red 63 Ruby Red 60 Chequers Red 118 Plexiglass 2423		
HDSP-2001 (Yellow)	Panelgraphic Yellow 27 Chequers Amber 107	Polaroid HNCP37 3M Light Control Film Panelgraphic Gray 10	Polaroid HNCP10-Glass Marks Polarized MPC-0301-8-10 Note 1
HDSP-2002 (HER)	Panelgraphic Ruby Red 60 Chequers Red 112	Chequers Grey 105	Polaroid HNCP10-Glass Marks Polarized MPC-0201-2-22
HDSP-2003 (HP Green)	Panelgraphic Green 48 Chequers Green 107		Polaroid HNCP10-Glass Marks Polarized MPC-0101-5-12

Note: 1. Optically coated circular polarized filters, such as Polaroid HNCP10.

Figure 9. Contrast Enhancement Filters

Mechanical and Thermal Considerations

The HDSP-2300/-2301/-2302/-2303 are available in standard ceramic dual-in-line packages. They are designed for plugging into sockets or soldering into PC boards. The packages may be horizontally or vertically stacked for character arrays of any desired size. The HDSP-2301/-2302/-2303 utilize a high output current IC to provide excellent readability in bright ambient lighting. Full power operation (V_{CC} = 5.25V, V_B = 2.4V, V_{COL} = 3.5V) with worst case thermal resistance from IC junction to ambient of 60° C/watt/device is possible up to ambient temperature of 37° C. For operation above 37° C, the maximum device dissipation should be derated linearly at 16.7 mW/° C (see Figure 5). With an improved thermal design, operation at higher ambient temperatures without derating is possible. Please refer to HP Application Note 1016 for further information.

The HDSP-2300 uses a lower power IC, yet achieves excellent readabilty in indoor ambient lighting. Full power operation up to T_A = 50° C (V_{CC} = 5.25V, V_B = 2.4V, V_{COL} = 3.5V) is possible by providing a total thermal resistance from IC junction to ambient of 60° C/watt/device maximum. For operation above 50° C, the maximum device dissipation should be derated at 16.7 mW/° C/device (see Figure 2).

Power derating for this family of displays can be achieved in several ways. The power supply voltage can be lowered to a minimum of 4.75V. Column Input Voltage, V_{COL}, can be decreased to the recommended minimum values of 2.6V for the HDSP-2300 and 2.75V for the HDSP-2301/-2302/-2303. Also, the average drive current can be decreased through pulse width modulation of V_B.

The HDSP-2300/-2301/-2302/-2303 displays have glass windows. A front panel contrast enhancement filter is desirable in most actual display applications. Some suggested filter materials are provided in Figure 9. Additional information on filtering and constrast enhancement can be found in HP Application Note 1015.

Post solder cleaning may be accomplished using water or Freon/alcohol mixtures formulated for vapor cleaning processing or Freon/alcohol mixtures formulated for room temperature cleaning. Freon/alcohol vapor cleaning processing for up to 2 minutes in vapors at boiling is permissible. Suggested solvents include Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15, and water.

NOTE:
The HDSP-2301/-2302/-2303 are available in high intensity categories suitable for some applications where direct sunlight viewing is required. For information on displays and filters for sunlight viewable applications, contact your field salesman.

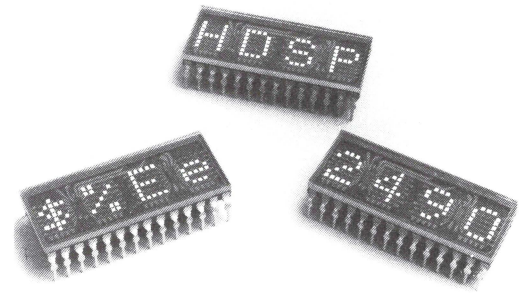
HEWLETT PACKARD

FOUR CHARACTER 6.9 mm (0.27 INCH) 5x7 ALPHANUMERIC DISPLAYS

STANDARD RED	HDSP-2490
YELLOW	HDSP-2491
HIGH EFFICIENCY RED	HDSP-2492
HIGH PERFORMANCE GREEN	HDSP-2493

Features

- **FOUR COLORS**
  Standard Red
  Yellow
  High Efficiency Red
  High Performance Green
- **INTEGRATED SHIFT REGISTERS WITH CONSTANT CURRENT DRIVERS**
- **COMPACT CERAMIC PACKAGE**
- **WIDE VIEWING ANGLE**
- **END STACKABLE FOUR CHARACTER PACKAGE**
- **TTL COMPATIBLE**
- **5 x 7 LED MATRIX DISPLAYS FULL ASCII SET**
- **CATEGORIZED FOR LUMINOUS INTENSITY**
- **HDSP-2491/2493 ALSO CATEGORIZED FOR COLOR**



Typical Applications

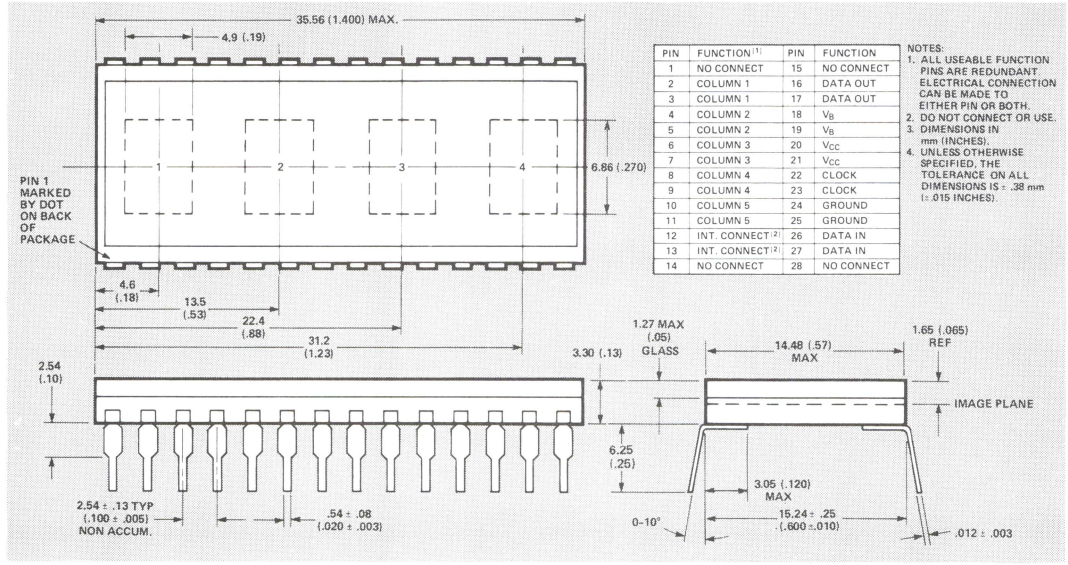
- **INSTRUMENTS**
- **BUSINESS MACHINES**
- **INDUSTRIAL PROCESS CONTROL EQUIPMENT**
- **MEDICAL INSTRUMENTS**
- **COMPUTER PERIPHERALS**
- **MILITARY GROUND SUPPORT EQUIPMENT**

Description

The HDSP-2490/-2491/-2492/-2493 series of displays are 6.9 mm (0.27 inch) 5 x 7 LED arrays for display of alphanumeric information. These devices are available in standard red, yellow, high efficiency red, and high performance green.

Each four character cluster is contained in a 28 pin dual-in-line package. An on-board SIPO (Serial-In-Parallel-Out) 7-bit shift register associated with each digit controls constant current LED row drivers. Full character display is achieved by external column strobing.

Package Dimensions



PIN	FUNCTION[1]	PIN	FUNCTION
1	NO CONNECT	15	NO CONNECT
2	COLUMN 1	16	DATA OUT
3	COLUMN 1	17	DATA OUT
4	COLUMN 2	18	V_B
5	COLUMN 2	19	V_B
6	COLUMN 3	20	V_{CC}
7	COLUMN 3	21	V_{CC}
8	COLUMN 4	22	CLOCK
9	COLUMN 4	23	CLOCK
10	COLUMN 5	24	GROUND
11	COLUMN 5	25	GROUND
12	INT. CONNECT[2]	26	DATA IN
13	INT. CONNECT[2]	27	DATA IN
14	NO CONNECT	28	NO CONNECT

NOTES:
1. ALL USEABLE FUNCTION PINS ARE REDUNDANT. ELECTRICAL CONNECTION CAN BE MADE TO EITHER PIN OR BOTH.
2. DO NOT CONNECT OR USE.
3. DIMENSIONS IN mm (INCHES).
4. UNLESS OTHERWISE SPECIFIED, THE TOLERANCE ON ALL DIMENSIONS IS ± .38 mm (± .015 INCHES).

Absolute Maximum Ratings (HDSP-2490/-2491/-2492/-2493)

Supply Voltage V_{CC} to Ground ..... —0.5V to 6.0V
Inputs, Data Out and V_B ..... —0.5V to V_{CC}
Column Input Voltage, V_{COL} ..... —0.5V to +6.0V
Free Air Operating
Temperature Range, T_A [1,2] ..... —20°C to +85°C
Storage Temperature Range, T_S ..... —55°C to +100°C
Maximum Allowable Power Dissipation
at $T_A = 25°C$ [1,2,3] ..... 1.46 Watts
Maximum Solder Temperature 1.59 mm (0.063 in.)
Below Seating Plane t < 5 sec ..... 260°C

Recommended Operating Conditions (HDSP-2490/-2491/-2492/-2493)

Parameter	Symbol	Min.	Nom.	Max.	Units	Fig.
Supply Voltage	V_{CC}	4.75	5.0	5.25	V	
Data Out Current, Low State	I_{OL}			1.6	mA	
Data Out Current, High State	I_{OH}			-0.5	mA	
Column Input Voltage, Column On HDSP-2490	V_{COL}	2.4		3.5	V	4
Column Input Voltage, Column On HDSP-2491/-2492/-2493	V_{COL}	2.75		3.5	V	4
Setup Time	t_{setup}	70	45		ns	1
Hold Time	t_{hold}	30	0		ns	1
Width of Clock	$t_{w(Clock)}$	75			ns	1
Clock Frequency	f_{clock}	0		3	MHz	1
Clock Transition Time	t_{THL}			200	ns	1
Free Air Operating Temperature Range [1,2]	T_A	-20		85	°C	2

Electrical Characteristics Over Operating Temperature Range

(Unless otherwise specified)

Description		Symbol	Test Conditions		Min.	Typ.*	Max.	Units	Fig.
Supply Current		I_{CC}	$V_{CC} = 5.25V$, $V_{CLOCK} = V_{DATA} = 2.4V$, All SR Stages = Logical 1	$V_B = 0.4V$		45	60	mA	
				$V_B = 2.4V$		73	95	mA	
Column Current at any Column Input		I_{COL}	$V_{CC} = 5.25$ V, $V_{COL} = 3.5V$	$V_B = 0.4V$			500	μA	4
Column Current at any Column Input		I_{COL}	All SR Stages = Logical 1	$V_B = 2.4V$		380	520	mA	
V_B, Clock or Data Input Threshold High		V_{IH}	$V_{CC} = V_{COL} = 4.75V$		2.0			V	
V_B, Clock or Data Input Threshold Low		V_{IL}					0.8	V	
Input Current Logical 1	V_B, Clock	I_{IH}	$V_{CC} = 5.25V$, $V_{IH} = 2.4V$			20	80	μA	
	Data In	I_{IH}				10	40	μA	
Input Current Logical 0	V_B, Clock	I_{IL}	$V_{CC} = 5.25V$, $V_{IL} = 0.4V$			-500	-800	μA	
	Data In	I_{IL}				-250	-400	μA	
Data Out Voltage		V_{OH}	$V_{CC} = 4.75V$, $I_{OH} = -0.5$ mA, $I_{COL} = 0$ mA		2.4	3.4		V	
		V_{OL}	$V_{CC} = 4.75V$, $I_{OL} = 1.6$ mA, $I_{COL} = 0$ mA			0.2	0.4	V	
Power Dissipation Per Package**		P_D	$V_{CC} = 5.0V$, $V_{COL} = 3.5V$, 17.5% DF, 15 LEDs on per character, $V_B = 2.4V$			0.78		W	2
Thermal Resistance IC Junction-to-Case		$R\theta_{J-C}$				20		°C/W/ Device	2

*All typical values specified at $V_{CC} = 5.0V$ and $T_A = 25°C$ unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

1. Operation above 85°C ambient is possible provided the following conditions are met. The junction should not exceed 125°C T_J and the case temperature (as measured at pin 1 or the back of the display) should not exceed 100°C T_C.
2. The device should be derated linearly above 60°C at 22.2 mW/°C. This derating is based on a device mounted in a socket having a thermal resistance from case to ambient at 25°C/W per device. See Figure 2 for power deratings based on a lower thermal resistance.
3. Maximum allowable dissipation is derived from $V_{CC} = 5.25V$, $V_B = 2.4V$, $V_{COL} = 3.5V$ 20 LEDs on per character, 20% DF.

Optical Characteristics

STANDARD RED HDSP-2490

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	220	370		μcd	3
Peak Wavelength	λ_{PEAK}			655		nm	
Dominant Wavelength[7]	λ_d			639		nm	

YELLOW HDSP-2491

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	850	1400		μcd	3
Peak Wavelength	λ_{PEAK}			583		nm	
Dominant Wavelength[5,7]	λ_d			585		nm	

HIGH EFFICIENCY RED HDSP-2492

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	850	1530		μcd	3
Peak Wavelength	λ_{PEAK}			635		nm	
Dominant Wavelength[7]	λ_d			626		nm	

HIGH PERFORMANCE GREEN HDSP-2493

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	1280	2410		μcd	3
Peak Wavelength	λ_{PEAK}			568		nm	
Dominant Wavelength[5,7]	λ_d			574		nm	

*All typical values specified at V_{CC} = 5.0V and T_A = 25° C unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

4. The characters are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
5. The HDSP-2491/-2493 are categorized for color with the color category designated by a number code on the bottom of the package.
6. T_j refers to the initial case temperature of the device immediately prior to the light measurement.
7. Dominant wavelength λ_d, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
8. The luminous sterance of the LED may be calculated using the following relationships:
   L_v (cd/m^2) = I_v (Candela)/A (Metre)^2
   L_v (Footlamberts) = πI_v (Candela)/A (Foot)^2
   A = 5.3 x 10^{-8} M^2 = 5.8 x 10^{-7} (Foot)^2

Electrical Description

The HDSP-249X series of four character alphanumeric displays have been designed to allow the user maximum flexibility in interface electronics design. Each four character display module features DATA IN and DATA OUT terminals arrayed for easy PC board interconnection. DATA OUT represents the output of the 7th bit of digit number 4 shift register. Shift register clocking occurs on the high to low transition of the clock input. The like columns of each character in a display cluster are tied to a single pin. Figure 5 is the block diagram for the displays. High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5 x 7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduction in power consumption.

In the normal mode of operation, input data for digit 4 column 1 is loaded into the 7 on-board shift register locations 1 through 7. Column 1 data for digits 3, 2 and 1 is similarly shifted into the display shift register locations. The column 1 input is now enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4 and 5. If the time necessary to decode and load data into the shift register is t, then with 5 columns, each column of the display is operating at a duty factor of:

$$D.F. = \frac{T}{5(t+T)}$$

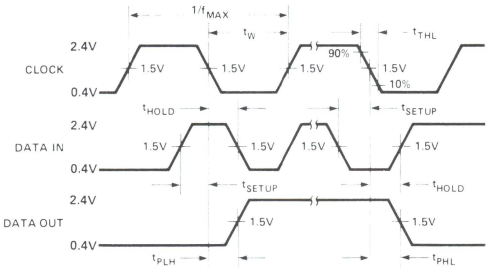
The time frame, t + T, alloted to each column of the display is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

With columns to be addressed, this refresh rate then gives a value for the time t + T of:

$$1/|5 \times (100)| = 2 \text{ msec}$$

If the device is operated at 3.0 MHz clock rate maximum, it is possible to maintain t << T. For short display strings, the duty factor will then approach 20%.

For further applications information, refer to HP Application Note 1016.



Parameter	Condition	Min.	Typ.	Max.	Units
f_{clock} CLOCK Rate				3	MHz
t_{PLH}, t_{PHL} Propagation delay CLOCK to DATA OUT	C_L = 15pF R_L=2.4KΩ			125	ns

Figure 1. Switching Characteristics HDSP-2490/-2491/-2492/-2493 (T_A = -20° C to +85° C)

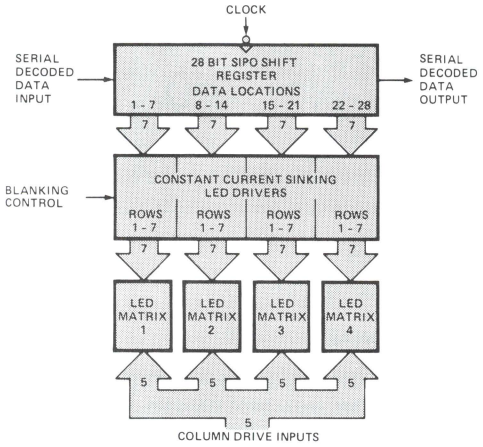


Figure 5. Block Diagram of HDSP-2490/-2491/-2492/-2493

Mechanical and Thermal Considerations

The HDSP-2490/-2491/-2492/-2493 are available in standard ceramic dual-in-line packages. They are designed for plugging into sockets or soldering into PC boards. The packages may be horizontally or vertically stacked for character arrays of any desired size. The HDSP-2490/-2491/-2492/-2493 utilize a high output current IC to provide excellent readability in bright ambient lighting. Full power operation (V_{CC} = 5.25V, V_B = 2.4V, V_{COL} = 3.5V) with worst case thermal resistance from IC junction to ambient of 45° C/watt/device is possible up to ambient temperature of 60° C. For operation above 60° C, the maximum device dissipation should be derated linearly at 22.2 mW/° C (see Figure 2). With an improved thermal design, operation at higher ambient temperatures without derating is possible. Please refer to Application Note 1016 for further information.

Power derating for this family of displays can be achieved in several ways. The power supply voltage can be lowered to a minimum of 4.75V. Column Input Voltage, V_{COL}, can be decreased to the recommended minimum values of 2.4V for the HDSP-2490 and 2.75V for the HDSP-2491/-2492/-2493. Also, the average drive current can be decreased through pulse width modulation of V_B.

The HDSP-2490/-2491/-2492/-2493 displays have glass windows. A front panel contrast enhancement filter is desirable in most actual display applications. Some suggested filter materials are provided in Figure 6. Additional information on filtering and contrast enhancement can be found in HP Application Note 1015.

Post solder cleaning may be accomplished using water or Freon/alcohol mixtures formulated for vapor cleaning processing or Freon/alcohol mixtures formulated for room temperature cleaning. Freon/alcohol vapor cleaning processing for up to 2 minutes in vapors at boiling is permissible. Suggested solvents include Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15, and water.

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
HDSP-2000 Std. Red	Panelgraphic Dark Red 63 Ruby Red 60 Chequers Red 118 Plexiglass 2423		
HDSP-2001 (Yellow)	Panelgraphic Yellow 27 Chequers Amber 107	Polaroid HNCP37 3M Light Control Film Panelgraphic Gray 10	Polaroid HNCP10-Glass Marks Polarized MPC-0301-8-10 Note 1
HDSP-2002 (HER)	Panelgraphic Ruby Red 60 Chequers Red 112	Chequers Grey 105	Polaroid HNCP10-Glass Marks Polarized MPC-0201-2-22
HDSP-2003 (HP Green)	Panelgraphic Green 48 Chequers Green 107		Polaroid HNCP10-Glass Marks Polarized MPC-0101-5-12

Note: 1. Optically coated circular polarized filters, such as Polaroid HNCP10.

Figure 6. Contrast Enhancement Filters

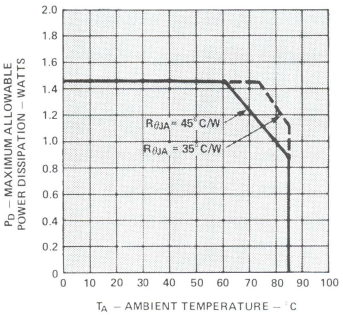


Figure 2. Maximum Allowable Power Dissipation vs. Temperature

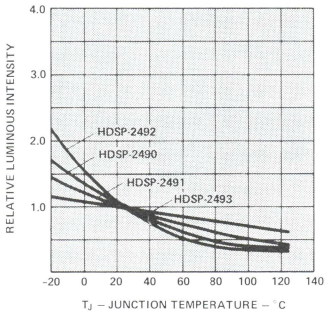


Figure 3. Relative Luminous Intensity vs. Temperature

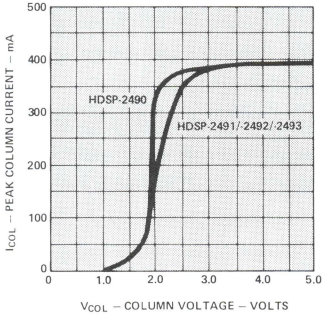


Figure 4. Peak Column Current vs. Column Voltage

HEWLETT PACKARD

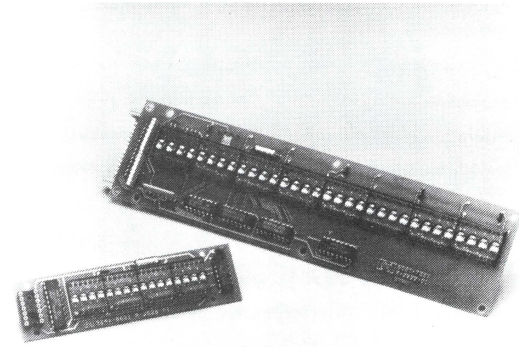
SMART DISPLAY BOARD FAMILY

16 AND 32 CHARACTER
2.85 mm (0.112) AND 4.1 mm (0.16)

HDSP-6621
HDSP-6624

Features

- FULLY ASSEMBLED
- FUNCTIONALLY TESTED
- INCLUDE ON-BOARD CHARACTER GENERATOR, MEMORY, DRIVER, DECODER, MULTIPLEX, AND BUFFER CIRCUITRY
- 64 ASCII CHARACTER SET
- ALL DIGITS ALIGNED AND MATCHED FOR INTENSITY
- 2.85 mm (0.112) or 4.1 mm (0.16) CHARACTER HEIGHT
- VIEWING ANGLE GREATER THAN ±40°
- SINGLE 5 V POWER SUPPLY
- FULL TTL COMPATIBILITY



Description

The HDSP-6621 and HDSP-6624 smart display systems are board assemblies based on the HPDL-1414 and HPDL-2416 displays. The HDSP-6621 consists of four HPDL-1414 displays (16 characters) plus a decoder and interface buffer on a single printed circuit board. The HDSP-6624 consists of eight HPDL-2416 displays (32 characters) plus a decoder and interface buffers on a single printed circuit board. Each display provides its own character memory, 64 character ASCII decoder ROM, and refresh circuitry necessary to synchronize the decoding and driving of four 17 segment red LEDs. The HDSP-6624 has the additional features of a cursor (all dots on) or a blanking (flashing) function. The characters in each system are aligned and matched for intensity.

The HDSP-662X family can be configured in custom string lengths, and the HDSP-6621 is available without a connector. Contact your local Hewlett-Packard field sales representative with your requirements.

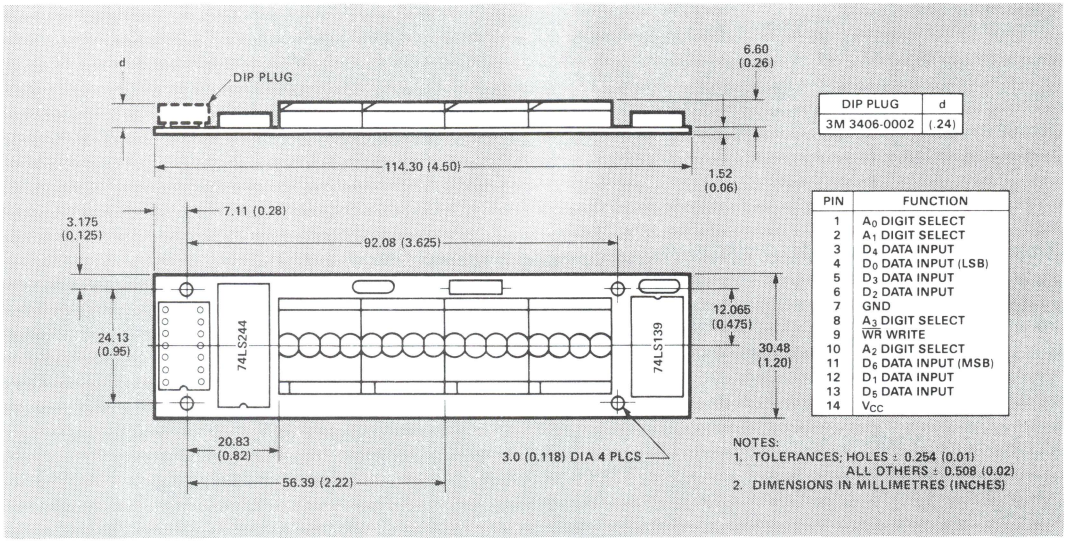
Typical Applications

- COMPUTER PERIPHERALS
- TELECOMMUNICATIONS
- INDUSTRIAL EQUIPMENT
- INSTRUMENTS

Absolute Maximum Ratings

Supply Voltage, V_{CC} to Ground ..... -0.3 to 7.0 V
Input Voltage, Any Pin to Ground ..... -0.3 to V_{CC}
Free Air Operating Temperature Range ..... 0°C to 70°C
Storage Temperature ..... -40°C to 85°C

Package Dimensions HDSP-6621

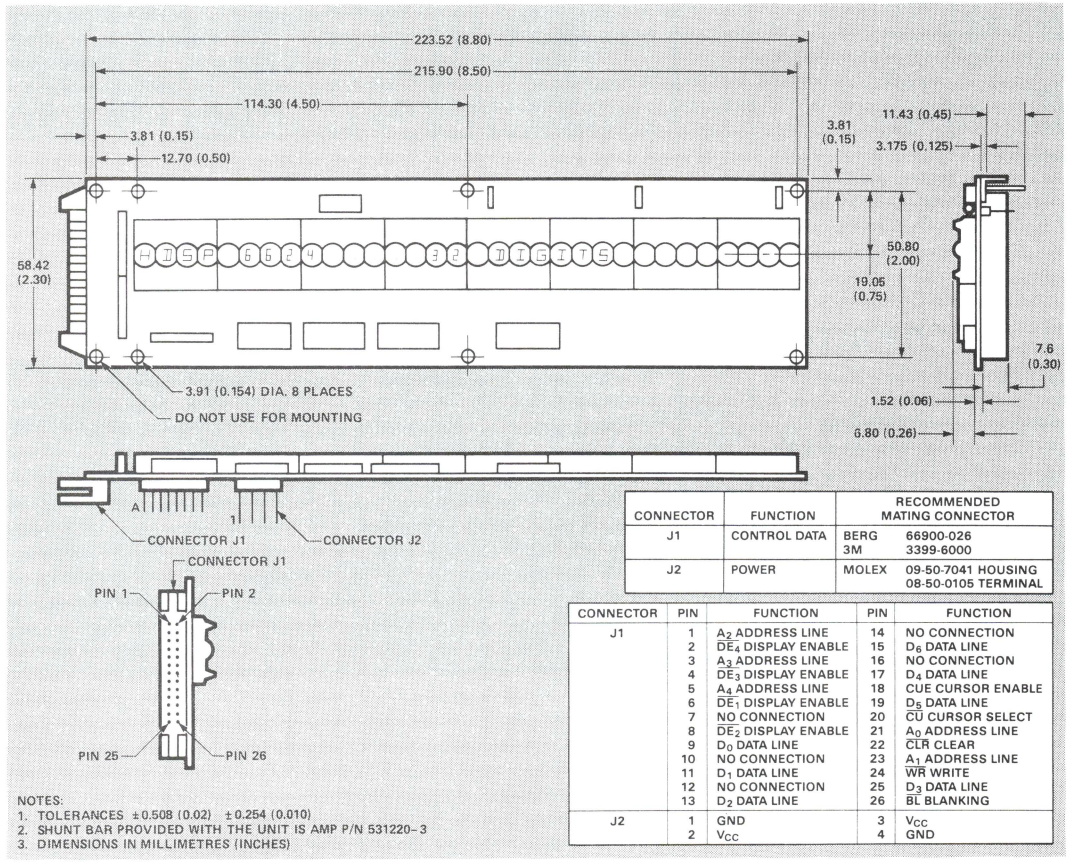


DIP PLUG	d
3M 3406-0002	(.24)

PIN	FUNCTION
1	A_0 DIGIT SELECT
2	A_1 DIGIT SELECT
3	D_4 DATA INPUT
4	D_0 DATA INPUT (LSB)
5	D_3 DATA INPUT
6	D_2 DATA INPUT
7	GND
8	A_3 DIGIT SELECT
9	$\overline{WR}$ WRITE
10	A_2 DIGIT SELECT
11	D_6 DATA INPUT (MSB)
12	D_1 DATA INPUT
13	D_5 DATA INPUT
14	V_{CC}

NOTES:
1. TOLERANCES: HOLES ± 0.254 (0.01)
   ALL OTHERS ± 0.508 (0.02)
2. DIMENSIONS IN MILLIMETRES (INCHES)

Package Dimensions HDSP-6624



CONNECTOR	FUNCTION	RECOMMENDED MATING CONNECTOR	
J1	CONTROL DATA	BERG 3M	66900-026 3399-6000
J2	POWER	MOLEX	09-50-7041 HOUSING 08-50-0105 TERMINAL

CONNECTOR	PIN	FUNCTION	PIN	FUNCTION
J1	1	$\overline{A_2}$ ADDRESS LINE	14	NO CONNECTION
	2	$\overline{DE_4}$ DISPLAY ENABLE	15	D_6 DATA LINE
	3	$\overline{A_3}$ ADDRESS LINE	16	NO CONNECTION
	4	$\overline{DE_3}$ DISPLAY ENABLE	17	D_4 DATA LINE
	5	$\overline{A_4}$ ADDRESS LINE	18	CUE CURSOR ENABLE
	6	$\overline{DE_1}$ DISPLAY ENABLE	19	$\overline{D_5}$ DATA LINE
	7	NO CONNECTION	20	$\overline{CU}$ CURSOR SELECT
	8	$\overline{DE_2}$ DISPLAY ENABLE	21	A_0 ADDRESS LINE
	9	D_0 DATA LINE	22	$\overline{CLR}$ CLEAR
	10	NO CONNECTION	23	$\overline{A_1}$ ADDRESS LINE
	11	D_1 DATA LINE	24	$\overline{WR}$ WRITE
	12	NO CONNECTION	25	$\overline{D_3}$ DATA LINE
	13	D_2 DATA LINE	26	$\overline{BL}$ BLANKING
J2	1	GND	3	V_{CC}
	2	V_{CC}	4	GND

NOTES:
1. TOLERANCES ±0.508 (0.02) ±0.254 (0.010)
2. SHUNT BAR PROVIDED WITH THE UNIT IS AMP P/N 531220-3
3. DIMENSIONS IN MILLIMETRES (INCHES)

Recommended Operating Conditions

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Input Voltage High	V_{IH}	2.0		V_{CC} + 0.3	V
Input Voltage Low	V_{IL}	GND - 0.3		0.8	V

Electrical Characteristics Over Operating Temperature Range

Parameter	HDSP-6621		HDSP-6624		Units	Test Conditions
	Typ.	Max.	Typ.	Max.		
I_{CC} All digits on (10 seg/digit)[1]	315		720		mA	V_{CC} = 5.0 V
		480		1200	mA	V_{CC} = 5.25 V
I_{CC} Cursor[2, 3] (HDSP-6624 only)			1040		mA	V_{CC} = 5.0 V
				1600	mA	V_{CC} = 5.25 V
I_{CC} Blank	40		30		mA	V_{CC} = 5.0 V
		75		80	mA	V_{CC} = 5.25 V
I_{IH} with pullup		NA		-2.85	mA	V_{CC} = 5.25 V, V_{IH} = 2.4 V
I_{IL} with pullup		NA		-4.85	mA	V_{CC} = 5.25 V, V_{IL} = 0.4 V
I_{IH} with pulldown		NA		2.4	mA	V_{CC} = 5.25 V, V_{IH} = 2.4 V
I_{IL} with pulldown		NA		0.4	mA	V_{CC} = 5.25 V, V_{IL} = 0.4 V
I_{IH} without resistor		40		40	μA	V_{CC} = 5.25 V, V_{IH} = 2.4 V
I_{IL} without resistor		-1.6		-1.6	mA	V_{CC} = 5.25 V, V_{IL} = 0.4 V

Notes:
1. "%" illuminated in all locations.
2. Cursor character is sixteen segments and DP on.
3. Cursor operates continuously over operating temperature range.

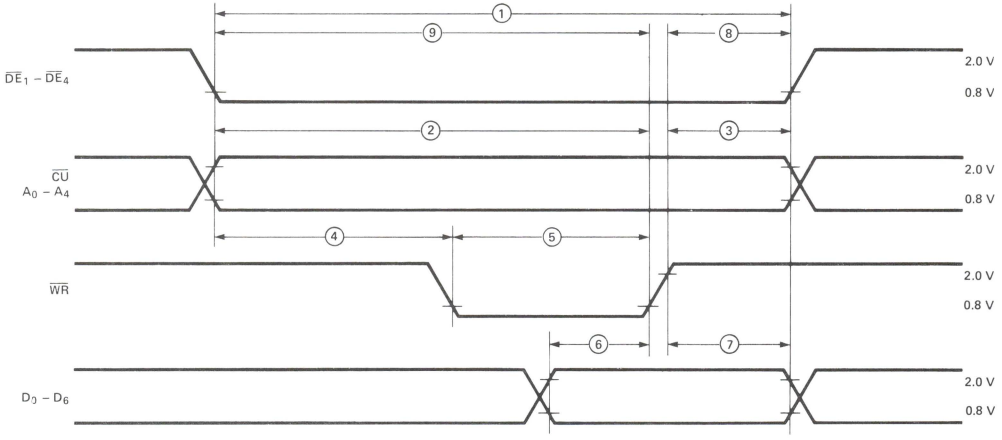
Optical Characteristics

Parameter		Symbol	Min.	Typ.	Units	Test Condition
Peak Luminous Intensity per digit, 8 segments on (character average)	HDSP-6624	I_VPeak	0.5	1.25	mcd	V_{CC} = 5.0 V "*" illuminated in all digits
	HDSP-6621		0.4	1.0		
Peak Wavelength		λPeak		655	nm	
Dominant Wavelength		λd		640	nm	
Off Axis Viewing Angle	HDSP-6624			±50	deg.	
	HDSP-6621			±40		
Digit Size	HDSP-6624			2.85	mm	
	HDSP-6621			4.1		

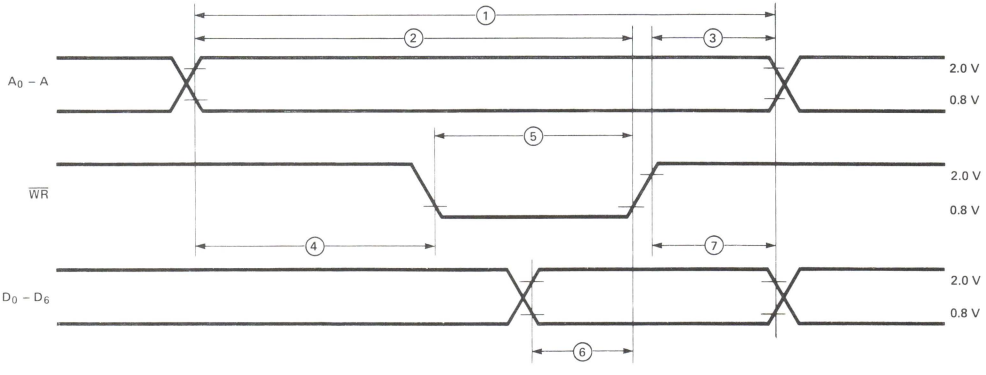
AC Timing Characteristics Over Operating Temperature Range

Reference Number	Parameter	Symbol	HDSP-6621		HDSP-6624		Units
			25°C Min.	70°C Min.	25°C Min.	70°C Min.	
1	Access Time	t_{ACC}	180	220	350	480	ns
2	Address Setup Time	t_{AS}	115	150	285	410	ns
3	Address Hold Time	t_{AH}	65	70	65	70	ns
4	Write Delay Time	t_{WD}	15	20	115	180	ns
5	Write Time	t_W	100	130	170	230	ns
6	Data Setup Time	t_{DS}	80	100	160	220	ns
7	Data Hold Time	t_{DH}	65	70	65	70	ns
8	Display Enable Hold Time	t_{DES}	N/A	N/A	65	70	ns
9	Display Enable Setup Time	t_{DEH}	N/A	N/A	285	410	ns
	Clear Time	t_{CLR}	3.5	4.0	3.5	4.0	ms
	Refresh Rate		310	270	310	270	Hz

TIMING DIAGRAM FOR THE HDSP-6621 DISPLAY SYSTEM



TIMING DIAGRAM FOR THE HDSP-6624 DISPLAY SYSTEM



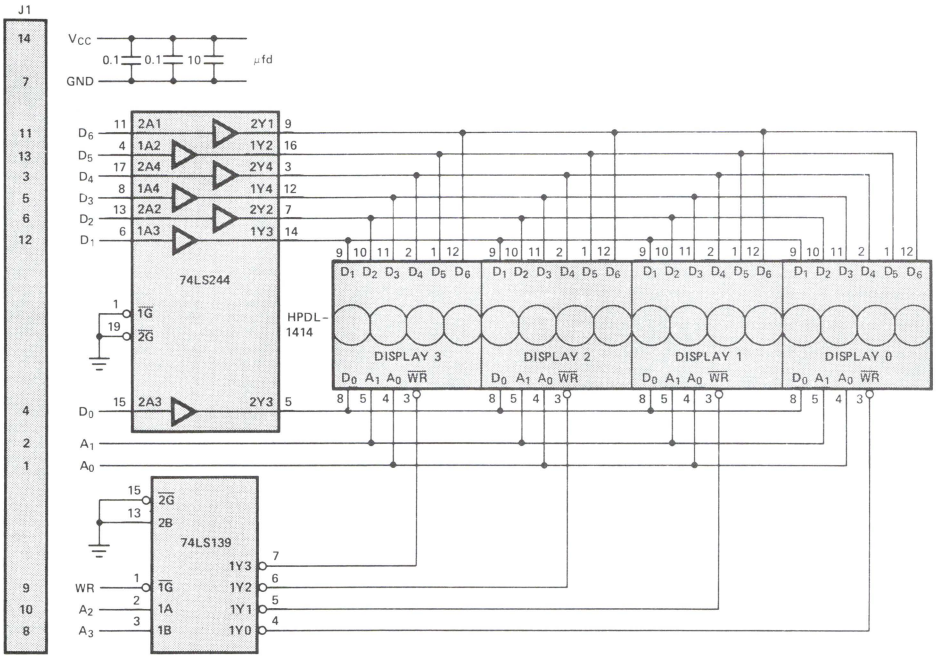


Figure 1. Circuit Diagram for the HDSP-6621

Display Interface

HDSP-6621

Figure 1 shows the circuit diagram for the HDSP-6621. Information is transferred to the display on a 4 pin connector. The following lines are available to the user to pass data to the display.

For a detailed explanation of the function of the pins see the HPDL-1414 data sheet. The HDSP-6621 has 2 Address lines which are not on the HPDL-1414.

Data lines (D_0-D_6) (pins 3-6, 11-13)	ASCII data is entered into the display on the Data lines.
Address lines (A_0-A_3) (pins 1-3, 8)	Each location in memory has a distinct address. Address inputs enable the designer to select a specific location in memory to store data. Address 0000 accesses the far right location and address 1111 accesses the far left location.
Write line ($\overline{WR}$) (pin 9)	Data is written into the display when the display write line is low and the display has been selected.

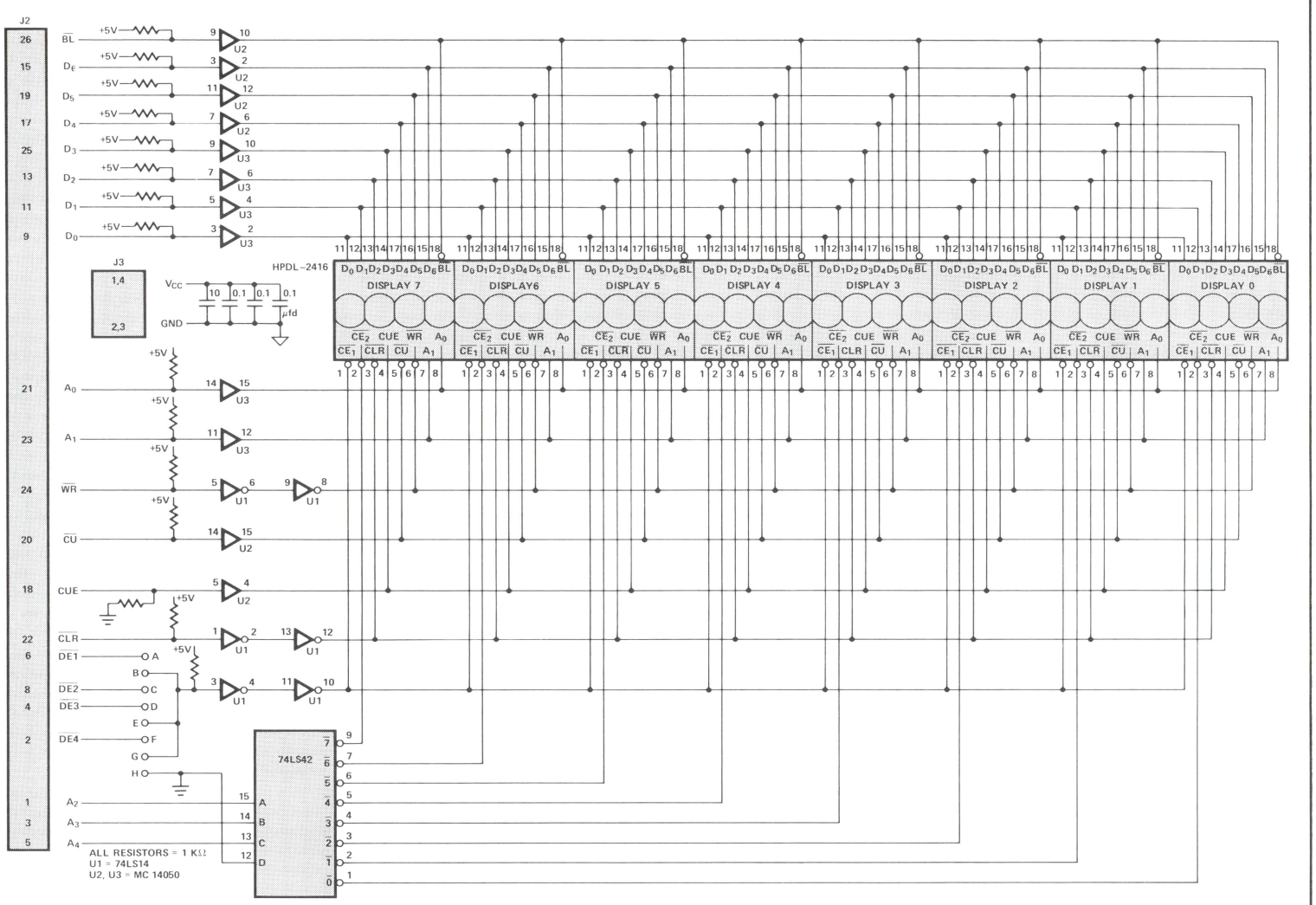


Figure 2. Circuit Diagram for the HDSP-6624

Display Interface

HDSP-6624

Figure 2 shows the circuit diagram for the HDSP-6624. Information is transferred to the display on a 26 pin connector. The following lines are available to the user to pass data to the display.

For a detailed explanation of the function of the pins see the HPDL-2416 Data Sheet. The HDSP-6624 has four display enable inputs and 3 address lines which are not on the HPDL-2416.

Data lines (D_0-D_6) (J2 pins 11, 13, 15, 17, 19, 25)	ASCII data or cursor data is entered into the display on the data lines.
Address lines (A_0-A_4) (J2 pins 1, 3, 5, 21, 23)	Each location in memory has a distinct address. Address inputs enable the designer to select a specific location in memory to store data. Address 00000 accesses the far right location. Address 11111 accesses the far left location.
Display Enables ($\overline{DE}_1$-$\overline{DE}_4$) (J2 pins 2, 4, 6, 8)	The user can connect any one of the four Display Enable inputs to all of the $\overline{CE}_2$ inputs of the HPDL-2416 displays. All that is required is to short the appropriate pins on the display board with the shorting plug. This allows the user to display the same character data on two or more systems or to display different data on up to four display boards. $\overline{DE}_1$ = shorting A and B $\overline{DE}_2$ = shorting B and C $\overline{DE}_3$ = shorting D and E $\overline{DE}_4$ = shorting E and F or F and G Shorting G and H will bypass $\overline{DE}_1$-$\overline{DE}_4$ and enable the device.
Write line ($\overline{WR}$) (J2 pin 24)	Data is written into the display when the Write line is low and the display has been selected.
Cursor Select line ($\overline{CU}$) (J2 pin 20)	This input is used to determine whether data is stored in ASCII memory or Cursor memory. (1 = ASCII, 0 = Cursor)
Cursor Enable line (CUE) (J2 pin 18)	This input is used to determine whether Cursor data is displayed. (1 = Cursor, 0 = ASCII)
Blanking input ($\overline{BL}$) (J2 pin 26)	The Blanking input can be used to create a flashing display or to blank the display without clearing the ASCII memory. This input inhibits the IC segment drivers and the display Clear function.
Clear input ($\overline{CLR}$) (J2 pin 22)	ASCII data will be removed from the ASCII Memory after the Clear input has been held at a logic low for 4 ms. The Cursor data is unaffected by the Clear input.

Using the Display Interface

Hewlett-Packard's Smart Display Systems can be treated as a block of RAM locations, whose purpose is to store and display 64 character ASCII data using a sixteen-segment character font as shown in Figure 3. To load data into the display system, the host system has to supply the ASCII data, the address and the proper control signals and the character will be stored in the location selected. See the timing diagram for the necessary timing and signal sequence.

BITS	D_3 D_2 D_1 D_0	0 0 0 0	0 0 0 1	0 0 1 0	0 0 1 1	0 1 0 0	0 1 0 1	0 1 1 0	0 1 1 1	1 0 0 0	1 0 0 1	1 0 1 0	1 0 1 1	1 1 0 0	1 1 0 1	1 1 1 0	1 1 1 1
D_6 D_5 D_4	HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0 1 0	2	(space)	!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
0 1 1	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
1 0 0	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1 0 1	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_

Figure 3. HDSP-6621/6624 ASCII Character Set

Design Considerations

These display systems use CMOS components that may be damaged by electrostatic discharge. These display systems can be safely handled by the PC board edges. To avoid static damage use standard CMOS handling procedures.

Cleaning may be performed with a solvent or aqueous process. The following solvents may be used without causing damage to the system:

Allied Chemical Genesolv DES
Baron Blakeslee Blaco-tron TES
DuPont Freon TE

Solvents containing alcohols, ketones and halogenated hydrocarbons will attack the nylon lens of the displays and should be avoided.

For additional information on handling and cleaning please refer to the HPDL-1414 and HPDL-2416 data sheets and Application Note 1026.

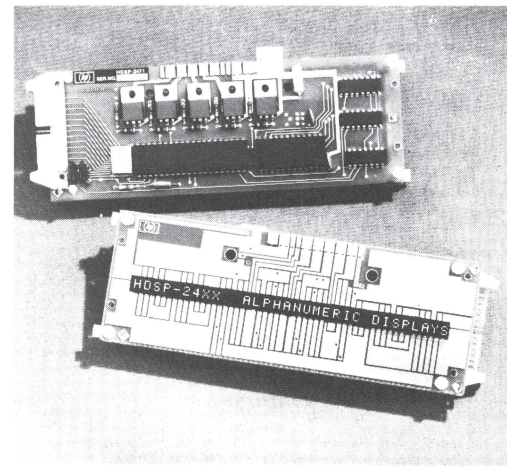
HEWLETT PACKARD

5 x 7 DOT MATRIX ALPHANUMERIC DISPLAY SYSTEM

HDSP - 2416
HDSP - 2424
HDSP - 2432
HDSP - 2440
HDSP - 2470
HDSP - 2471
HDSP - 2472

Features

- **COMPLETE ALPHANUMERIC DISPLAY SYSTEM UTILIZING THE HDSP-2000 DISPLAY**
- **CHOICE OF 64, 128, OR USER DEFINED ASCII CHARACTER SET**
- **CHOICE OF 16, 24, 32, or 40 ELEMENT DISPLAY PANEL**
- **MULTIPLE DATA ENTRY FORMATS — Left, Right, RAM, or Block Entry**
- **EDITING FEATURES THAT INCLUDE CURSOR, BACKSPACE, FORWARDSPACE, INSERT, DELETE, AND CLEAR**
- **DATA OUTPUT CAPABILITY**
- **SINGLE 5.0 VOLT POWER SUPPLY**
- **TTL COMPATIBLE**
- **EASILY INTERFACED TO A KEYBOARD OR A MICROPROCESSOR**



Typical Applications

- **DATA ENTRY TERMINALS**
- **INSTRUMENTATION**
- **BUSINESS EQUIPMENT**
- **COMPUTER PERIPHERALS**

Description

The HDSP-24XX series of alphanumeric display systems provides the user with a completely supported 5 x 7 dot matrix display panel. These products free the user's system from display maintenance and minimize the interaction normally required for alphanumeric displays. Each alphanumeric display system is composed of two component parts:

1. An alphanumeric display controller which consists of a preprogrammed microprocessor plus associated logic, which provides decode, memory, and drive signals necessary to properly interface a user's system to an HDSP-2000 display. In addition to these basic display support operations, the controller accepts data in any of four data entry formats and incorporates several powerful editing routines.
2. A display panel which consists of HDSP-2000 displays matched for luminous intensity and mounted on a P.C. board designed to have low thermal resistance.

These alphanumeric display systems are also available in high efficiency red, yellow, and green. In addition, they are available using the HDSP-2300 or HDSP-2490 series displays to form display systems with larger characters (5.0 mm and 6.9 mm, respectively). Contact your local HP sales office for more information.

PART NUMBER	DESCRIPTION
Display Boards	
HDSP-2416	Single-line 16 character display panel utilizing the HDSP-2000 display
HDSP-2424	Single-line 24 character display panel utilizing the HDSP-2000 display
HDSP-2432	Single-line 32 character display panel utilizing the HDSP-2000 display
HDSP-2440	Single-line 40 character display panel utilizing the HDSP-2000 display
Controller Boards	
HDSP-2470	HDSP-2000 display interface incorporating a 64 character ASCII decoder
HDSP-2471	HDSP-2000 display interface incorporating a 128 character ASCII decoder
HDSP-2472	HDSP-2000 display interface without ASCII decoder. Instead, a 24 pin socket is provided to accept a custom 128 character set from a user programmed 1K x 8 PROM.

When ordering, specify one each of the Controller Board and the Display Board for each complete system.

HDSP-2470/-2471/-2472

Absolute Maximum Ratings

V_{CC} ..... -0.5V to 6.0V

Operating Temperature Range, Ambient (T_A) ..... 0°C to 70°C

Storage Temperature Range (T_S) .... -55°C to 100°C

Voltage Applied to any Input or Output ..-0.5V to 6.0V

I_{SOURCE} Continuous for any Column Driver ..... 5.0 Amps (60 sec. max. duration)

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.25	V
Data Out	I_{OL}		0.4	mA
	I_{OH}		-20	μA
Ready, Data Valid, Column On, Display Data	I_{OL}		1.6	mA
	I_{OH}		-40	μA
Clock	I_{OL}		10.0	mA
	I_{OH}		-1.0	mA
$Column_{1-5}$	I_{SOURCE}		-5.0	A

Electrical Characteristics Over Operating Temperature Range

(Unless otherwise specified)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Supply Current[1]	I_{CC}			400	mA	V_{CC} = 5.25V Column On and All Outputs Open
Input Threshold High (except Reset)	V_{IH}	2.0			V	V_{CC} = 5.0V ± .25V
Input Threshold High — Reset[2]	V_{IH}	3.0			V	V_{CC} = 5.0V ± .25V
Input Threshold Low — All Inputs	V_{IL}			0.8	V	V_{CC} = 5.0V ± .25V
Data Out Voltage	V_{OH}Data	2.4			V	I_{OH} = -20μA V_{CC} = 4.75V
	V_{OL}Data			0.5	V	I_{OL} = 0.4mA V_{CC} = 4.75V
Clock Output Voltage	V_{OH}Clk	2.4			V	I_{OH} = -1000μA V_{CC} = 4.75V
	V_{OL}Clk			0.5	V	I_{OL} = 10.0mA V_{CC} = 4.75V
Ready, Display Data, Data Valid, Column on Output Voltage	V_{OH}	2.4			V	I_{OH} = -40μA V_{CC} = 4.75V
	V_{OL}			0.5	V	I_{OL} = 1.6mA V_{CC} = 4.75V
Input Current,[3] All Inputs Except Reset, Chip Select, D_7	I_{IH}			-0.3	mA	V_{IH} = 2.4V V_{CC} = 5.25V
	I_{IL}			-0.6	mA	V_{IL} = 0.5V V_{CC} = 5.25V
$\overline{\text{Reset}}$ Input Current	I_{IH}			-0.3	mA	V_{IH} = 3.0V V_{CC} = 5.25V
	I_{IL}			-0.6	mA	V_{IL} = 0.5V V_{CC} = 5.25V
Chip Select, D_7 Input Current	I_I	-10		+10	μA	0 < V_I < V_{CC}
Column Output Voltage	V_{OL}COL	2.6	3.2		V	I_{OUT} = -5.0A V_{CC} = 5.00V

NOTES:

1. See Figure 11 for total system supply current.
2. External reset may be initiated by grounding Reset with either a switch or open collector TTL gate for a minimum time of 50ms. For Power On Reset to function properly, V_{CC} power supply should turn on at a rate > 100V/s.
3. Momentary peak surge currents may exist on these lines. However, these momentary currents will not interfere with proper operation of the HDSP-2470/1/2.

Absolute Maximum Ratings

Supply Voltage V_{CC} to Ground ..... -0.5V to 6.0V
Inputs, Data Out and V_B ..... -0.5V to V_{CC}
Column Input Voltage, V_{COL} ..... -0.5V to +6.0V
Free Air Operating Temperature Range, T_A[1] ..... 0°C to +55°C
Storage Temperature Range, T_S .... -55°C to +100°C

Recommended Operating Conditions

Parameter	Symbol	Min.	Norm.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Column Input Voltage, Column On	V_{COL}	2.6			V
Setup Time	t_{SETUP}	70	45		ns
Hold Time	t_{HOLD}	30	0		ns
Width of Clock	$t_{W(CLOCK)}$	75			ns
Clock Frequency	f_{CLOCK}	0		3	MHz
Clock Transition Time	t_{THL}			200	ns
Free Air Operating[1] Temperature Range	T_A	0		55	°C

Electrical Characteristics Over Operating Temperature Range

(Unless otherwise specified)

Parameter		Symbol	Min.	Typ.*	Max.	Units	Conditions	
Supply Current		I_{CC}		45n	60n[2]	mA	V_{CC} = 5.25V, V_{CLOCK}=V_{DATA}=2.4V, All SR Stages = Logical 1	V_B = 0.4V
				73n	95n	mA		V_B = 2.4V
Column Current at any Column Input		I_{COL}			1.5n	mA	V_{CC} = V_{COL} = 5.25V, All SR Stages = Logical 1	V_B = 0.4V
		I_{COL}		335n	410n	mA		V_B = 2.4V
Peak Luminous Intensity per LED (Character Average)		$I_{V\ PEAK}$	105	200		μcd	V_{CC} = 5.0V, V_{COL} = 3.5V, T_j = 25°C[3], V_B = 2.4V	
V_B, Clock or Data Input Threshold High		V_{IH}	2.0			V	V_{CC} = V_{COL} = 4.75V	
V_B, Clock or Data Input Threshold Low		V_{IL}			0.8	V		
Input Current Logical 1	V_B, Clock	I_{IH}			80	μA	V_{CC} = 5.25V, V_{IH} = 2.4V	
	Data In	I_{IH}			40	μA		
Input Current Logical 0	V_B, Clock	I_{IL}		-500	-800	μA	V_{CC} = 5.25V, V_{IL} = 0.4V	
	Data In	I_{IL}		-250	-400	μA		
Power Dissipation Per Board[4]		P_D		0.66n		W	V_{CC} = 5.0V, V_{COL} = 2.6V, 15 LED's on per Character, V_B = 2.4V	

*All typical values specified at V_{CC} = 5.0V and T_A = 25°C unless otherwise noted.

NOTES:

1. Operation above 55°C (70°C MAX) may be achieved by the use of forced air (150 fpm normal to component side of HDSP-247X controller board at sea level). Operation down to -20°C is possible in applications that do not require the use of HDSP-2470/-2471/-2472 controller boards.
2. n = number of HDSP-2000 packages
   HDSP-2416 n = 4
   HDSP-2424 n = 6
   HDSP-2432 n = 8
   HDSP-2440 n = 10
3. Tj refers to initial case temperature immediately prior to the light measurement.
4. Power dissipation with all characters illuminated.

System Overview

The HDSP-2470/-2471/-2472 Alphanumeric Display Controllers provide the interface between any ASCII based Alphanumeric System and the HDSP-2000 Alphanumeric Display. ASCII data is loaded into the system by means of any one of four data entry modes — Left, Right, RAM or Block Entry. This ASCII data is stored in the internal RAM memory of the system. The system refreshes HDSP-2000 displays from 4 to 48 characters with the decoded data.

The user interfaces to any of the systems through eight DATA IN inputs, five ADDRESS inputs (RAM mode), a CHIP SELECT input, RESET input, seven DATA OUT outputs, a READY output, DATA VALID output, and a COLUMN ON output. A low level on the RESET input clears the display and initializes the system. A low level on the CHIP SELECT input causes the system to load data from the DATA IN and ADDRESS inputs into the system. The controller outputs a status word, cursor address and 32 ASCII data characters through the DATA OUT outputs and DATA VALID output during the time the system is waiting to refresh the next column of the display. The COLUMN ON output can be used to synchronize the DATA OUT function. A block diagram for the HDSP-2470/-2471/-2472 systems is shown in Figure 1.

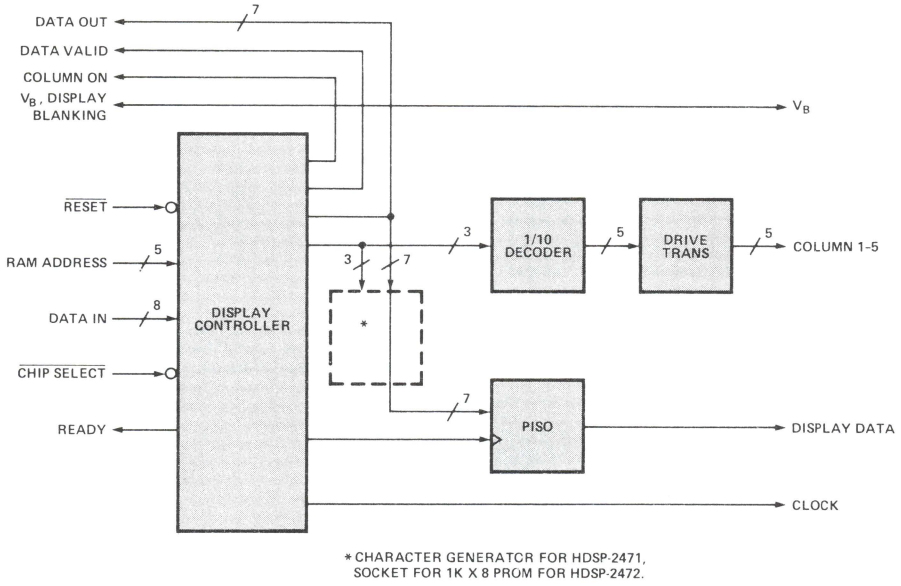


Figure 1. Block Diagram for the HDSP-2470/-2471/-2472 Alphanumeric Display Controller.

The system interfaces to the HDSP-2000 display through five COLUMN outputs, a CLOCK output, DISPLAY DATA output, and the COLUMN ON output. The user should connect DISPLAY DATA to DATA IN of the leftmost HDSP-2000 cluster and cascade DATA OUT to DATA IN of all HDSP-2000 clusters. COLUMN outputs from the system are connected to the COLUMN inputs of all HDSP-2000 clusters. The HDSP-24XX Series display boards are designed to interconnect directly with the HDSP-247X Series display controllers. The COLUMN outputs can source enough current to drive up to 48 characters of the HDSP-2000 display. Pulse width modulation of display luminous intensity can be provided by connecting COLUMN ON to the input of a monostable multivibrator and the output of the monostable multivibrator to the V_B inputs of the HDSP-2000 displays. The system is designed to refresh the display at a fixed refresh rate of 100 Hz. COLUMN ON time is optimized for each display length in order to maximize light output as shown in Figure 2.

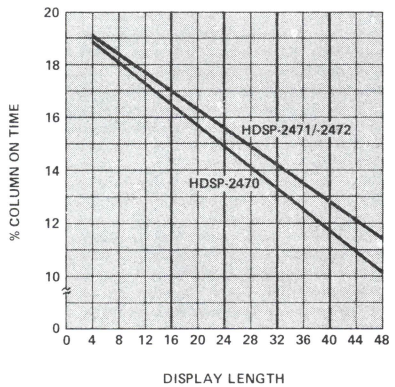


Figure 2. Column on Time vs. Display Length for the HDSP-2470/-2471/-2472 Alphanumeric Display Controller.

Control Mode/Data Entry

User interface to the HDSP-247X Series controller is via an 8 bit word which provides to the controller either a control word or standard ASCII data input. In addition to this user provided 8 bit word, two additional control lines, CHIP SELECT and READY, allow easily generated "handshake" signals for interface purposes.

A logic low applied to the CHIP SELECT input (minimum six microseconds) causes the controller to read the 8 DATA IN lines and determine whether a control word or ASCII data word is present, as determined by the logic state of the most significant bit (D_7). If the controller detects a logic high at D_7, the state of D_6-D_0 will define the data entry mode and the number of alphanumeric characters to be displayed.

The 8 bit control data word format is outlined in Figure 3. For the control word (D_7 high), bits D_6 and D_5 define the selected data entry mode (Left entry, Right entry, etc.) and bits D_3 to D_0 define display length. Bit D_4 is ignored.

Control word inputs are first checked to verify that the control word is valid. The system ignores display lengths greater than 1011 for left block or right, or 0111 for RAM. If the word is valid, the present state—next state table shown in Figure 4 is utilized to determine whether or not to clear the display. For display lengths of up to 32 characters, RAM entry can be used as a powerful editing tool, or can be used to preload the cursor. With other transitions, the internal data memory is cleared.

CONTROL WORD: $D_7D_6D_5D_4D_3D_2D_1D_0$

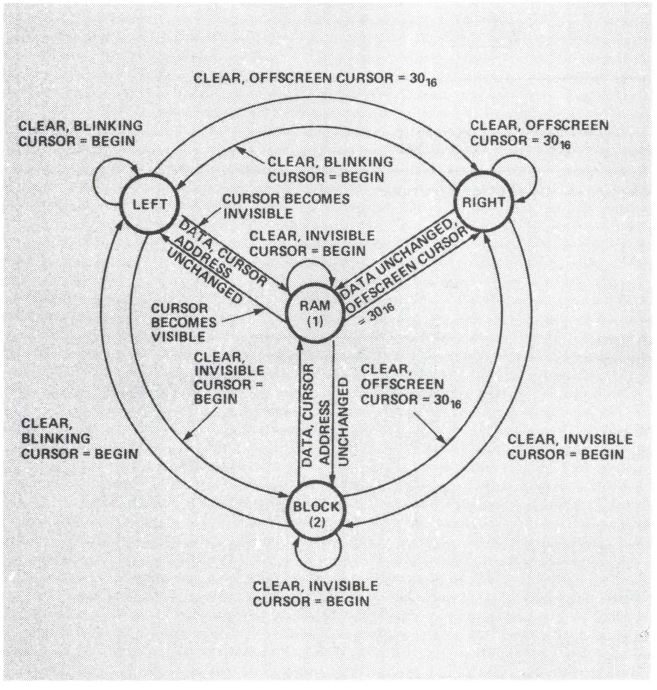
1	X	X	–	Y	Y	Y	Y

Y Y Y Y	DISPLAY LENGTH:
0 0 0 0	4 DIGITS
0 0 0 1	8 "
0 0 1 0	12 "
0 0 1 1	16 "
0 1 0 0	20 "
0 1 0 1	24 "
0 1 1 0	28 "
0 1 1 1	32* "
1 0 0 0	36 "
1 0 0 1	40 "
1 0 1 0	44 "
1 0 1 1	48 "

*maximum for RAM data entry mode

X X	DATA ENTRY MODES
0 0	RAM DATA ENTRY
0 1	LEFT DATA ENTRY
1 0	RIGHT DATA ENTRY
1 1	BLOCK DATA ENTRY

Figure 3. Control Word Format for the HDSP-2470/-2471/-2472 Alphanumeric Display Controller.



(1) RAM ENTRY MODE IS VALID FOR DISPLAYS OF 32 CHARACTERS OR LESS IN LENGTH.

(2) FOLLOWING A TRANSITION FROM RAM TO BLOCK, WHEN THE CURSOR ADDRESS IS 48 (30_{16}) DURING THE TRANSITION, THE FIRST VALID ASCII CHARACTER WILL BE IGNORED AND THE SECOND VALID ASCII CHARACTER WILL BE LOADED IN THE LEFT-MOST DISPLAY LOCATION.

WHERE BEGIN IS DEFINED AS FOLLOWS:

DISPLAY LENGTH	CURSOR ADDRESS OF BEGIN
4	$2C_{16}$, 44_{10}
8	28_{16}, 40_{10}
12	24_{16}, 36_{10}
16	20_{16}, 32_{10}
20	$1C_{16}$, 28_{10}
24	18_{16}, 24_{10}
28	14_{16}, 20_{10}
32	10_{16}, 16_{10}
36	$0C_{16}$, 12_{10}
40	08_{16}, 8_{10}
44	04_{16}, 4_{10}
48	00_{16}

Figure 4. Present State-Next State Diagram for the HDSP-2470/-2471/-2472 Alphanumeric Display Controller.

If D_7 is a logic low when the DATA IN lines are read, the controller will interpret D_6-D_0 as standard ASCII data to be stored, decoded and displayed. The system accepts seven bit ASCII for all three versions. However, the HDSP-2470 system displays only the 64 character subset [20_{16} (space) to $5F_{16}$ (_)] and ignores all ASCII characters outside this subset with the exception of those characters defined as display commands. These display commands are shown in Figure 5. Displayed character sets for the HDSP-2470/-2471 systems are shown in Figure 6.

DATA WORD:	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		
ASCII ASSIGNMENT	0	A	A	A	A	A	A	A	DISPLAY COMMAND	
LF	0	0	0	1	0	1	0		CLEAR	Valid in Right Entry Mode
BS	0	0	0	1	0	0	0		BACKSPACE CURSOR	Valid in Right Entry Mode
HT	0	0	0	1	0	0	1		FORWARDSPACE CURSOR	Valid in Left Entry Mode
US	0	0	1	1	1	1	1		INSERT CHARACTER	Valid in Left Entry Mode
DEL	1	1	1	1	1	1	1		DELETE CHARACTER	Valid in Left Entry Mode

Figure 5. Display Commands for the HDSP-2470/-2471/-2472 Alphanumeric Display Controller.

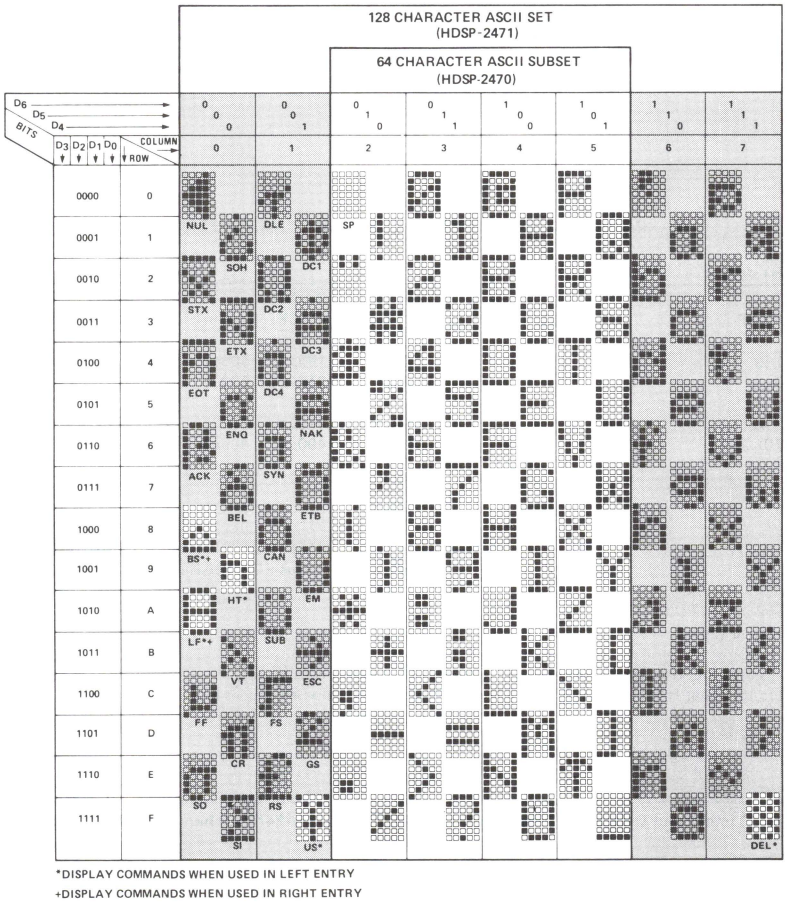
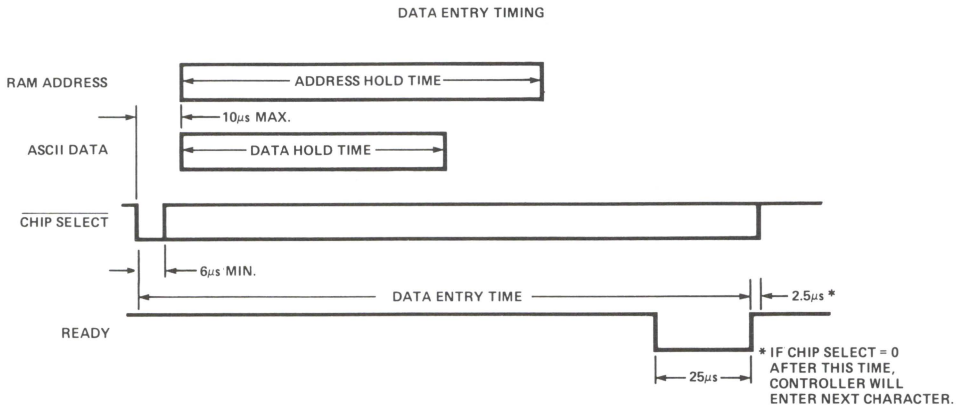


Figure 6. Display Font for the HDSP-2470 (64 Character ASCII Subset), and HDSP-2471 (128 Character ASCII Set) Alphanumeric Display Controller.

Regardless of whether a control word or ASCII data word is presented by the user, a READY signal is generated by the controller after the input word is processed. This READY signal goes low for 25μs and upon a positive transition, a new CHIP SELECT may be accepted by the controller. Data Entry Timing is shown in Figure 7.



MAXIMUM DATA ENTRY TIMES OVER OPERATING TEMPERATURE RANGE

DATA ENTRY MODE			FUNCTION					
HDSP-	DATA HOLD TIME*		DATA ENTRY	BACK SPACE	CLEAR	FORWARD SPACE	DELETE	INSERT
LEFT (2471/2)	135μs		235μs	195μs	505μs	205μs	725μs	725μs
LEFT (2470)	150μs		245μs	215μs	530μs	225μs	745μs	735μs
RIGHT (2471/2)	85μs		480μs	470μs	465μs			
RIGHT (2470)	105μs		490μs	490μs	485μs			
RAM (2471/2)	55μs	120μs**	190μs					
RAM (2470)	55μs	130μs**	200μs					
BLOCK (2471/2)	55μs		120μs	(155μs FOR RIGHTMOST CHARACTER)				
BLOCK (2470)	55μs		130μs	(165μs FOR RIGHTMOST CHARACTER)				
LOAD CONTROL (2471/2)	50μs		505μs					
LOAD CONTROL (2470)	50μs		505μs					

*Minimum time that data inputs must remain valid after Chip Select goes low.
**Minimum time that RAM address inputs must remain valid after Chip Select goes low.

Figure 7. Data Entry Timing and Data Entry Times for the HDSP-2470/-2471/-2472 Alphanumeric Display Controller.

Left Entry Mode

With Left entry, characters are entered in typewriter fashion, i.e., to the right of all previous characters. Left entry uses a blinking cursor to indicate the location where the next character is to be entered. CLEAR loads the display with spaces and resets the cursor to the leftmost display location. BACKSPACE and FORWARDSPACE move the cursor without changing the character string. Thus, the user can backspace to the character to be edited, enter a character and then forward space the cursor. The DELETE function deletes the displayed character at the cursor location and then shifts the character string following the cursor one location to the left to fill the void of the deleted character. The INSERT CHARACTER sets a flag inside the system that causes subsequent ASCII characters to be inserted to the left of the character at the cursor location. As new characters are entered, the cursor, the character at the cursor, and all characters to the right of the cursor are shifted one location to the right. The INSERT function is terminated by a second INSERT CHARACTER, or by BACKSPACE, FORWARDSPACE, CLEAR or DELETE. In Left entry mode, after the display is filled, the system ignores all characters except BACKSPACE and CLEAR. The system allows the cursor to be positioned only in the region between the leftmost display character and immediately to the right (offscreen) of the rightmost display character.

Right Entry Mode

In Right entry mode, characters are entered at the right hand side of the display and shifted to the left as new characters are entered. In this mode, the system stores 48 ASCII characters, although only the last characters entered are displayed. CLEAR loads the display with spaces. BACKSPACE shifts the display one location to the right, deleting the last character entered and displaying the next character in the 48 character buffer. Right entry mode is a simple means to implement the walking or "Times-Square" display. FORWARDSPACE, INSERT, and DELETE have character assignments in this mode since they are not treated as editing characters. In this mode, the cursor is located immediately to the right (offscreen) of the rightmost displayed character.

Block Entry Mode

Block entry allows the fastest data entry rate of all four modes. In this mode, characters are loaded from left to right as with Left entry. However, with Block entry, after the display is completely loaded, the next ASCII character is loaded in the leftmost display location, replacing the previous displayed character. While Block entry has a nonvisible cursor, the cursor is always loaded with the address of the next character to be entered. In this entry mode, the system can display the complete 128 character ASCII set. The display can be cleared and the cursor reset to the leftmost display location by loading in a new BLOCK control word.

RAM Entry Mode

In RAM entry, ASCII characters are loaded at the address specified by the five bit RAM address. Due to the limitation of only five address lines, RAM data entry is allowed only for displays less than or equal to 32 characters. Regardless of display length, address 00 is the leftmost display character. Out of range RAM addresses are ignored. While RAM entry has a non-visible cursor, the cursor is always preloaded with the address to the right of the last character entered. This allows the cursor to be preloaded with an address prior to going into any other entry mode. In RAM entry, the system can display the complete 128 character ASCII set because it does not interpret any of the characters as control functions. The display can be cleared by loading in a new RAM control word.

Data Out

For display lengths of 32 characters or less, the data stored in the internal RAM is available to the user during the time between display refresh cycles. The system outputs a STATUS WORD, CURSOR ADDRESS, and 32 ASCII data characters. The STATUS WORD specifies the data entry mode and the display length of the system. The STATUS WORD output differs slightly from the CONTROL WORD input. This difference is depicted in Figure 8. Regardless of display length, the CURSOR ADDRESS of the rightmost character location is address 47 ($2F_{16}$) and the offscreen address of the cursor is address 48 (30_{16}). The CURSOR ADDRESS of the leftmost location is defined as address 48 minus the display length. A general formula for CURSOR ADDRESS is:

CURSOR ADDRESS =

(47 - Display Length) + Number of Characters from Left.

For example, suppose the alphanumeric display is 16 characters long and the cursor was blinking at the third digit from the left. Then the CURSOR ADDRESS would be 47 - 16 + 3 or 34 (22_{16}) and the 18th ASCII data word would correspond to the ASCII character at the location of the display cursor. In Left and Block entry, the CURSOR ADDRESS specifies the location where the next ASCII data character is to be entered. In RAM entry, the CURSOR ADDRESS specifies the location to the right of the last character entered. In Right entry, the CURSOR ADDRESS is always 48 (30_{16}). The negative edge of the DATA VALID output can be used to load the 34 DATA OUT words into the user's system. The DATA OUT timing for the HDSP-247X systems are summarized in Figure 8. For displays longer than 32 characters, the system only outputs the STATUS WORD between refresh cycles.

Master/Power On Reset

When power is first applied to the system, the system clears the display and tests the state of the DATA INPUT, D_7. If $D_7 > 2.0V$, the systems loads the control word on the DATA INPUTS into the system. If $D_7 \leq .8V$ or the system sees an invalid control word, the system initializes as Left entry for a 32 character display with a flashing cursor in the leftmost location. For POWER ON RESET to function properly, the power supply must turn on at a rate > 100 V/s. In addition, the system can be reset by pulling the RESET input low for a minimum of 50 milliseconds. POWER ON/MASTER RESET timing is shown in Figure 9.

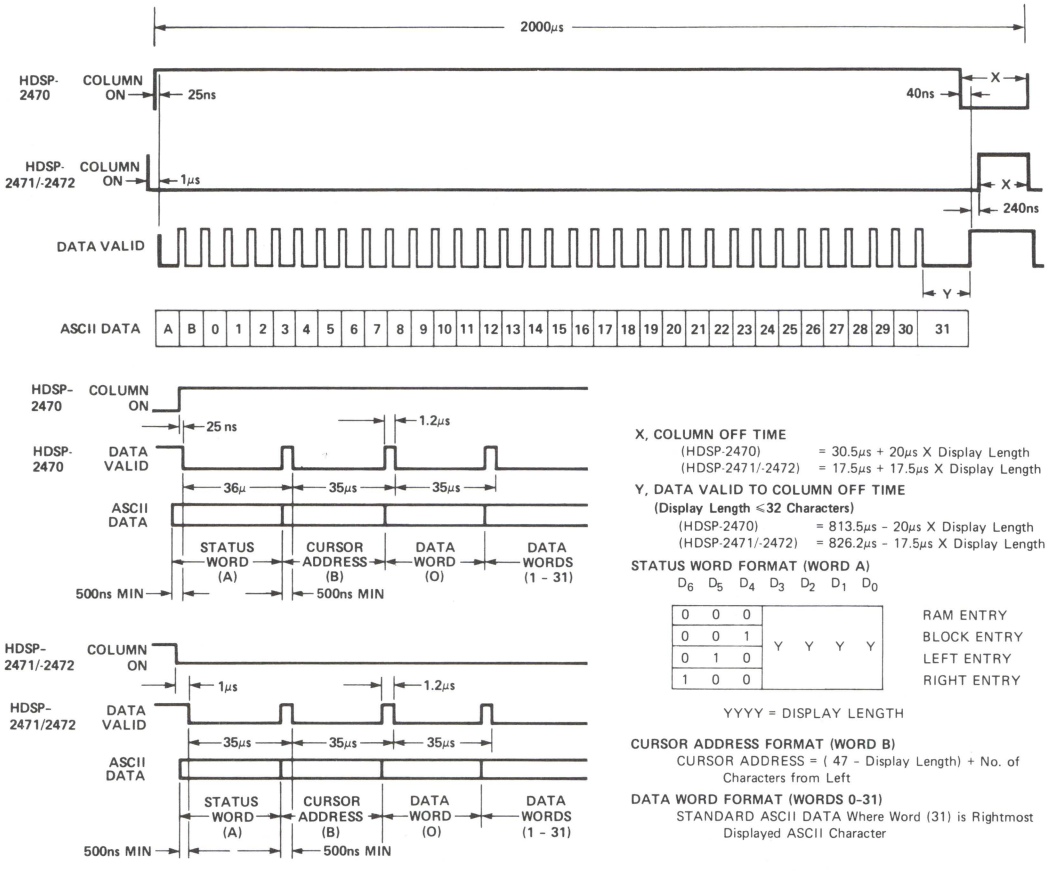


Figure 8. Data Out Timing and Format for the HDSP-2470/-2471/-2472 Alphanumeric Display Controller.

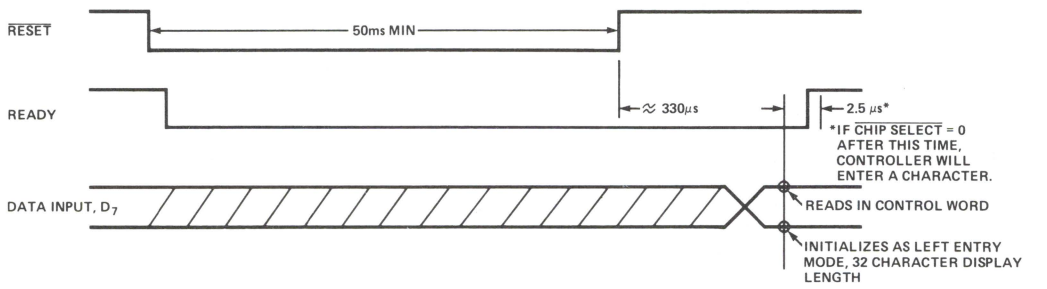


Figure 9. Power-On/Master Reset Timing for the HDSP-2470/-2471/-2472 Alphanumeric Display Controller.

Custom Character Sets

The HDSP-2472 system has been specifically designed to permit the user to insert a custom 128 ASCII character set. This system features a 24 pin socket that is designed to accept a custom programmed 1K X 8 PROM, EPROM, or ROM. The read only memory should have an access time $\leq 500_{ns}$, $I_{IL} \leq |-.4mA|$ and $I_{IH} \leq 40\mu A$. A list of pin compatible read only memories is shown in Figure 10. Jumper locations are provided on the HDSP-2472 P.C. board which allow the use of ROM's requiring chip enables tied either to 0 or 5V. For further information on ROM programming, please contact the factory.

Power Supply Requirements

The HDSP-247X Alphanumeric Display System is designed to operate from a single 5 volt supply. Total I_{CC} requirements for the HDSP-247X Alphanumeric Display Controller and HDSP-24XX Display Panel are shown in Figure 11. Peak I_{CC} is the instantaneous current required for the system. Maximum Peak I_{CC} occurs for $V_{CC} = 5.25V$ with 7 dots ON in the same Column in all display characters. This current must be supplied by a combination of the power supply and supply filter capacitor. Maximum Average I_{CC} occurs for $V_{CC} = 5.25V$ with 21 dots ON per character in all display characters. The inclusion of a 375 X microfarad capacitor (where X is the number of characters in the display) adjacent to the HDSP-247X Alphanumeric Display System will permit the use of a power supply capable of supplying the maximum average I_{CC}.

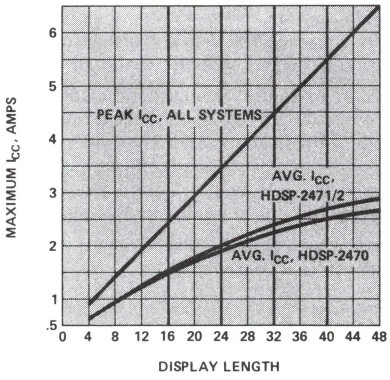


Figure 11. Maximum Peak and Average I_{CC} for the HDSP-2470/71/72 Alphanumeric Display Controller and HDSP-2000 Display.

CONNECTORS

FUNCTION	TYPE OF CONNECTOR	SUGGESTED MANUFACTURER
CONTROL/DATA ENTRY	26 Pin Ribbon Cable	3M P/N 3399-X000 Series
POWER(1)	3 Pin With Locking Ramp	Molex P/N 09-50-3031 with 08-50-0106 Terminals
DISPLAY DRIVE(2,3)	17 Pin Board to Board Pin/Socket	Pin: BERG p/n 75409-041 Socket: BERG p/n 65780-017

NOTES:
(1) Power leads should be 18-20 gauge stranded wire.
(2) The maximum lead length from the controller board to the display should not exceed 1 metre.

PART NUMBER	MANUFACTURER	TYPE	CONSTRUCTION	EXTERNAL CONNECTION* X	Y	Z
2758	Intel	EPROM	NMOS	GND	GND	+5
7608	Harris	PROM	BIPOLAR-NiCr	NC	NC	NC
3628-4	Intel	PROM	BIPOLAR-Si	+5	+5	GND
82S2708	Signetics	PROM	BIPOLAR-NiCr	NC	NC	NC
6381	Monolithic Mem.	PROM	BIPOLAR-NiCr	+5	+5	GND
6385	Monolithic Mem.	PROM	BIPOLAR-NiCr	NC	NC	NC
87S228	National	PROM	BIPOLAR-TiW	+5	+5	GND
93451	Fairchild	PROM	BIPOLAR-NiCr	+5	+5	GND
68308	Motorola	ROM	NMOS	**	NC	NC
2607	Signetics	ROM	NMOS	**	NC	NC
30000	Mostek	ROM	NMOS	**	+5	NC

*Board jumpers correspond to pins 18, 19 & 21 of ROM.

**As defined by customer

Figure 10. Pin Compatible 1K x 8 Read Only Memories for the HDSP-2472 Alphanumeric Display Controller.

Display Boards/Hardware

The mechanical layout of the HDSP-247X Series allows direct mating of the controller P.C. board to a compatible series of display boards available from Hewlett-Packard. These display boards consist of matched and tested HDSP-2000 clusters soldered to a P.C. board.

Included with the controller board are four locking circuit board support nylon standoffs (Richco LCBS-4). This hardware allows the controller board to interconnect with any of the standard display boards. Figure 12 depicts correct assembly technique.

Assembly Steps

1. Insert the standoffs into .151 diameter holes (noted as "S" on Figure 12. The long end of the standoffs should protrude through the controller board side.
2. Position the controller board and display board with the components and displays facing out. The HP logo should be in the upper left corner when viewed facing the boards. Insert the standoffs through the mating holes on the display board and press the boards together so that the standoffs lock in place.
3. Insert the pins from the display board into the socket on the controller board.

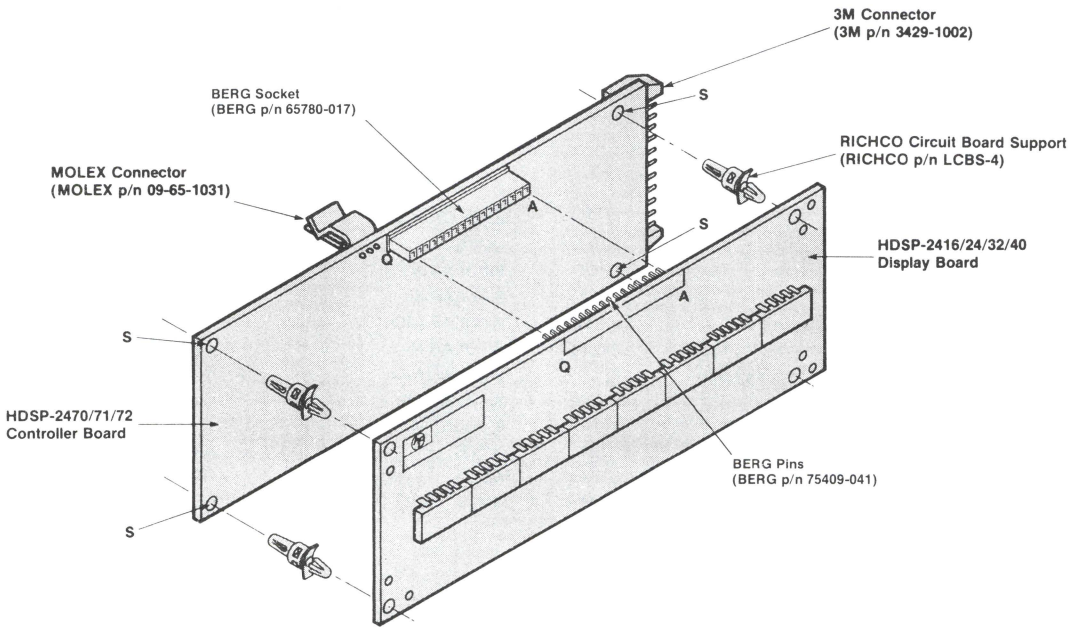


Figure 12. Assembly Drawing.

Package Dimensions

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN mm AND (INCHES)

HDSP-2470/-2471/-2472

PIN	DESCRIPTION
1	CHIP SELECT
2	DATA VALID
3	RAM ADDRESS, A_8
4	DATA IN, D_7
5	RAM ADDRESS, A_1
6	RESET
7	RAM ADDRESS, A_2
8	DATA OUT, DO_6
9	RAM ADDRESS, A_3
10	DATA OUT, DO_5
11	DATA IN, D_0
12	DATA OUT DO_4
13	DATA IN, D_1
14	DATA OUT, DO_3
15	DATA IN, D_2
16	DATA OUT, DO_2
17	DATA IN, D_3
18	DATA OUT, DO_1
19	DATA IN, D_4
20	DATA OUT, DO_0
21	DATA IN, D_5
22	READY
23	DATA IN, D_6
24	COLUMN ON
25	RAM ADDRESS, A_4
26	DISPLAY BLANK, V_B

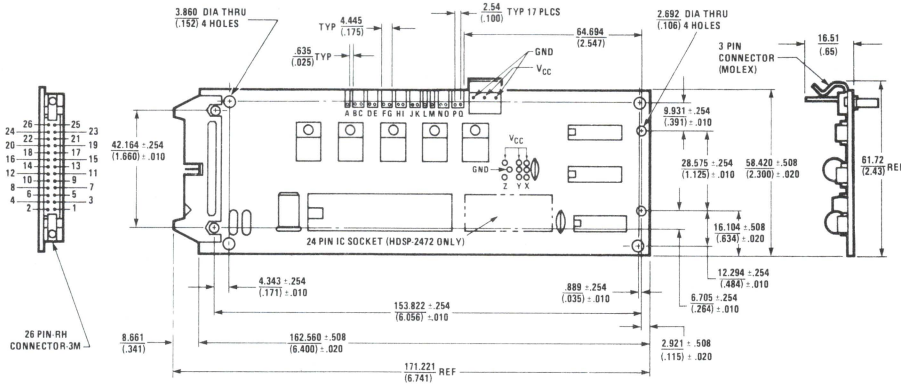


Figure 13. HDSP-2470/-2471/-2472

HDSP-2416/-2424/-2432/-2440
HDSP-2470/-2471/-2472

PIN	DESCRIPTION
A	DISPLAY BLANK, V_B
B,C	COLUMN$_1$
D,E	COLUMN$_2$
F,G	COLUMN$_3$
H,I	COLUMN$_4$
J,K	COLUMN$_5$
L	CLOCK
M	DISPLAY DATA
N,O	V_{CC}
P,Q	GND

A	HDSP-2416	71.120 (2.800)
B	HDSP-2424	106.680 (4.200)
C	HDSP-2432	142.240 (5.600)

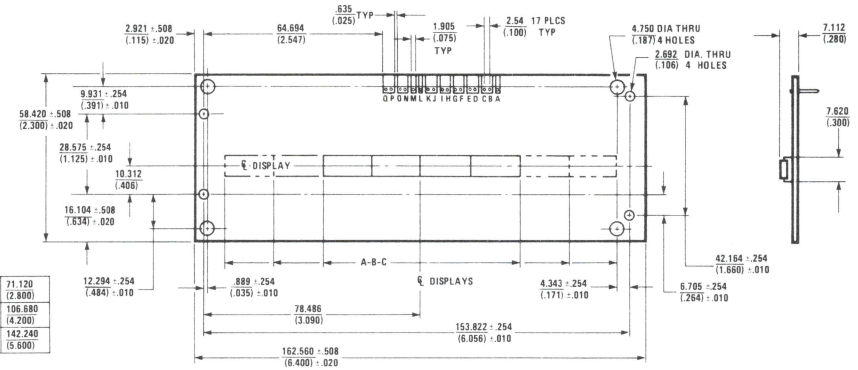


Figure 14. HDSP-2416/-2424/-2432

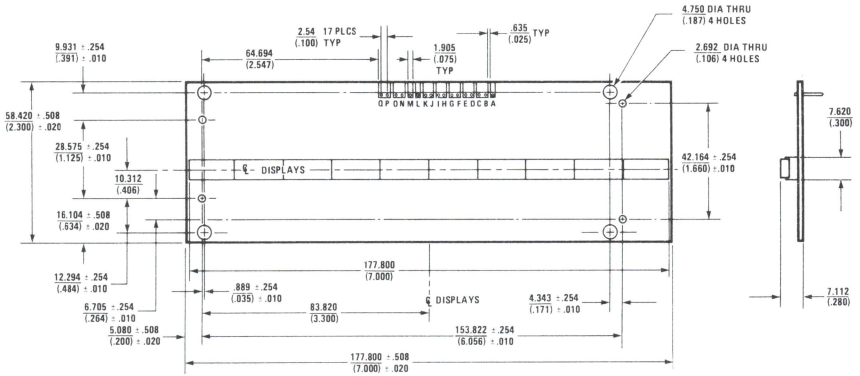


Figure 15. HDSP-2440

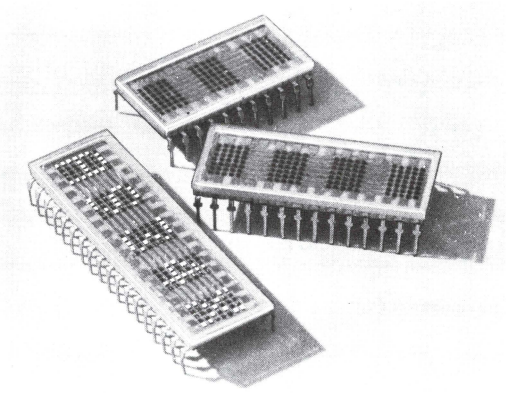
HEWLETT PACKARD

LED SOLID STATE ALPHANUMERIC INDICATOR

5082-7100
5082-7101
5082-7102

Features

- 5 x 7 LED MATRIX CHARACTER
- LARGE 6.9 mm (.27 INCH) CHARACTER HEIGHT
- EXTREMELY WIDE TEMP. RANGE
- COMPACT 15.2 mm (.600 INCH) GLASS/CERAMIC DIP
- WIDE VIEWING ANGLE
- RUGGED, SHOCK RESISTANT



Typical Applications

- COMPUTER PERIPHERALS
- MILITARY EQUIPMENT
- INDUSTRIAL EQUIPMENT
- AVIONICS

Description

The Hewlett-Packard 5082-7100 Series is an X-Y addressable, 5 x 7 LED Matrix capable of displaying the full alphanumeric character set. This alphanumeric indicator series is available in 3, 4, or 5 character end-stackable clusters. The clusters permit compact presentation of information, ease of character alignment, minimum number of interconnections, and compatibility with multiplexing driving schemes.

The **5082-7100** is a three character cluster.
The **5082-7101** is a four character cluster.
The **5082-7102** is a five character cluster.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units
Peak Forward Current Per LED (Duration < 1 ms)	I_{PEAK}		100	mA
Average Current Per LED	I_{AVG}		10	mA
Power Dissipation Per Character (All diodes lit) [1]	P_D		700	mW
Operating Temperature, Case	T_C	–55	95	°C
Storage Temperature	T_S	–55	100	°C
Reverse Voltage Per LED	V_R		4	V

Note 1: At 25°C Case Temperature; derate 8.5 mW/°C above 25°C.

Electrical / Optical Characteristics at T_C=25°C

Parameter	Symbol	Min.	Typ.	Max.	Units
Peak Luminous Intensity Per LED (Character Average) @ Pulse Current of 100mA/LED	$I_{\nu\ (PEAK)}$	1.0	2.2		mcd
Reverse Current Per LED @ V_R = 4V	I_R		10		μA
Peak Forward Voltage @ Pulse Current of 50mA/LED	V_F		1.7	2.0	V
Peak Wavelength	λ_{PEAK}		655		nm
Spectral Line Halfwidth	$\Delta\lambda_{1/2}$		30		nm
Rise and Fall Times [1]	t_r, t_f		10		ns

Note 1. Time for a 10% - 90% change of light intensity for step change in current.

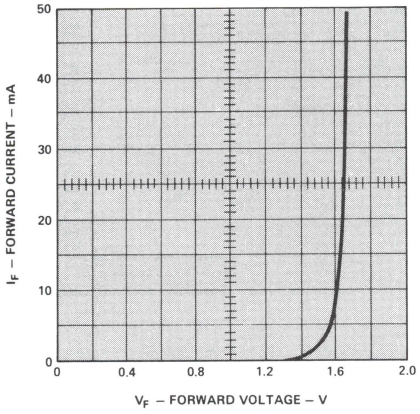


Figure 1. Forward Current-Voltage Characteristic.

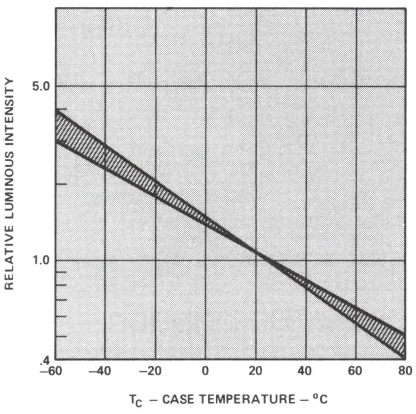


Figure 2. Relative Luminous Intensity vs. Case Temperature at Fixed Current Level.

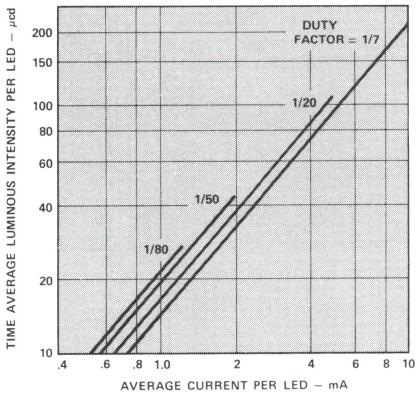


Figure 3. Typical Time Average Luminous Intensity per LED vs. Average Current per LED.

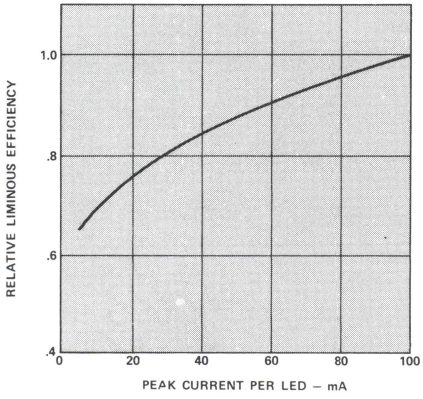
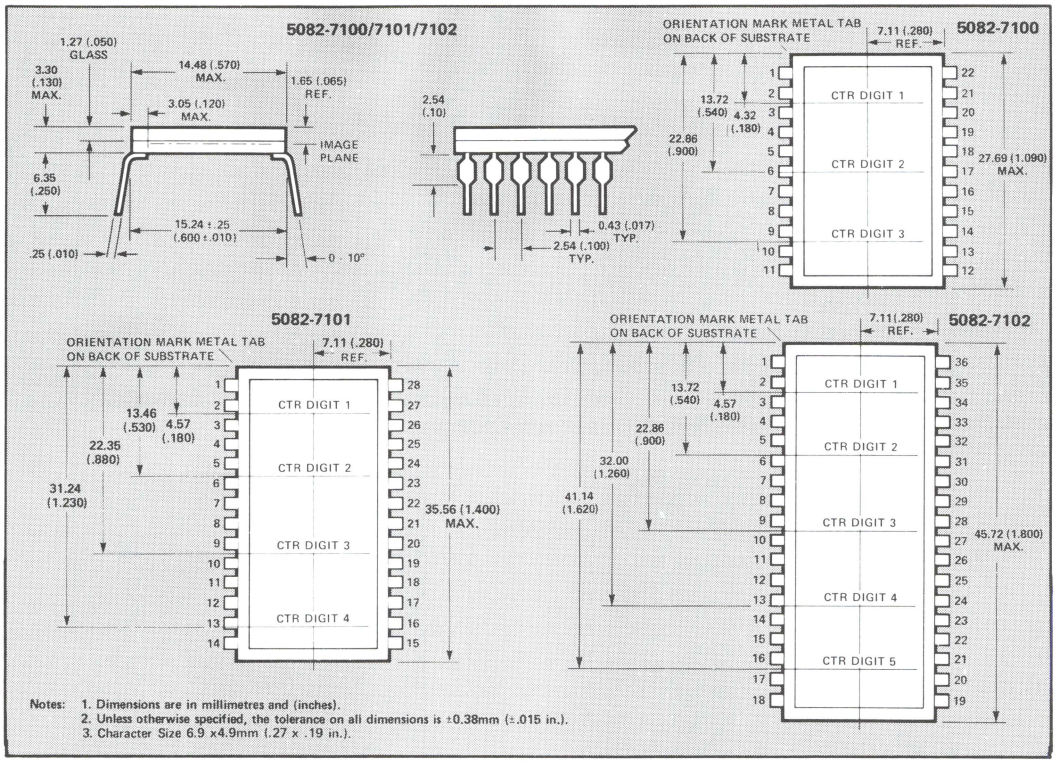


Figure 4. Typical Relative Luminous Efficiency vs. Peak Current per LED.

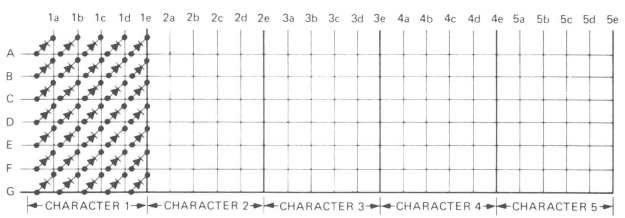
Package Dimensions and Pin Configurations



Notes:
1. Dimensions are in millimetres and (inches).
2. Unless otherwise specified, the tolerance on all dimensions is ±0.38mm (±.015 in.).
3. Character Size 6.9 x4.9mm (.27 x .19 in.).

Device Pin Description

5082-7100				5082-7101				5082-7102			
Pin	Function	Pin	Function	Pin	Function	Pin	Function	Pin	Function	Pin	Function
1	Anode G	12	Anode B	1	N/C	15	Anode C	1	N/C	19	5e
2	1c	13	3d	2	1c	16	4c	2	1c	20	5c
3	1d	14	3b	3	1e	17	4a	3	1e	21	5a
4	Anode F	15	Anode A	4	Anode G	18	Anode B	4	Anode F	22	Anode D
5	Anode E	16	2e	5	2b	19	3e	5	2b	23	4e
6	2b	17	2c	6	2d	20	3b	6	2d	24	4c
7	2d	18	2a	7	Anode D	21	3a	7	2e	25	N/C
8	Anode C	19	Anode D	8	Anode E	22	2e	8	Anode E	26	Anode C
9	3a	20	1e	9	3c	23	2c	9	3c	27	3d
10	3c	21	1b	10	3d	24	2a	10	3e	28	3b
11	3e	22	1a	11	Anode F	25	Anode A	11	Anode G	29	3a
				12	4b	26	1d	12	4a	30	Anode B
				13	4d	27	1b	13	4b	31	2c
				14	4e	28	1a	14	4d	32	2a
								15	N/C	33	Anode A
								16	5b	34	1d
								17	5d	35	1b
								18	N/C	36	1a



5082-7100/7101/7102
Schematic Wiring Diagram

Operating Considerations

ELECTRICAL

The 5 x 7 matrix of LED's, which make up each character, are X-Y addressable. This allows for a simple addressing, decoding and driving scheme between the display module and customer furnished logic.

There are three main advantages to the use of this type of X-Y addressable array:

1. It is an elementary addressing scheme and provides the least number of interconnection pins for the number of diodes addressed. Thus, it offers maximum flexibility toward integrating the display into particular applications.
2. This method of addressing offers the advantage of sharing the Read-Only-Memory character generator among several display elements. One character generating ROM can be shared over 25 or more 5 x 7 dot matrix characters with substantial cost savings.
3. In many cases equipment will already have a portion of the required decoder/driver (timing and clock circuitry plus buffer storage) logic circuitry available for the display.

To form alphanumeric characters a method called "scanning" or "strobing" is used. Information is addressed to the display by selecting one row of diodes at a time, energizing the appropriate diodes in that row and then proceeding to the next row. After all rows have been excited one at a time, the process is repeated. By scanning through all rows at least 100 times a second, a flicker free character can be produced. When information moves sequentially from row to row of the display (top to bottom) this is row scanning, as illustrated in Figure 5. Information can also be moved from column to column (left to right across the display) in a column scanning mode. For most applications (5 or more characters to share the same ROM) it is more economical to use row scanning.

MECHANICAL/THERMAL MOUNTING

The solid state display typically operates with 200 mW power dissipation per character. However, if the operating conditions are such that the power dissipation exceeds the derated maximum allowable value, the device should be heat sunk. The usual mounting technique combines mechanical support and thermal heat sinking in a common structure. A metal strap or bar can be mounted behind the display using silicone grease to insure good thermal control. A well-designed heat sink can limit the case temperature to within 10°C of ambient.

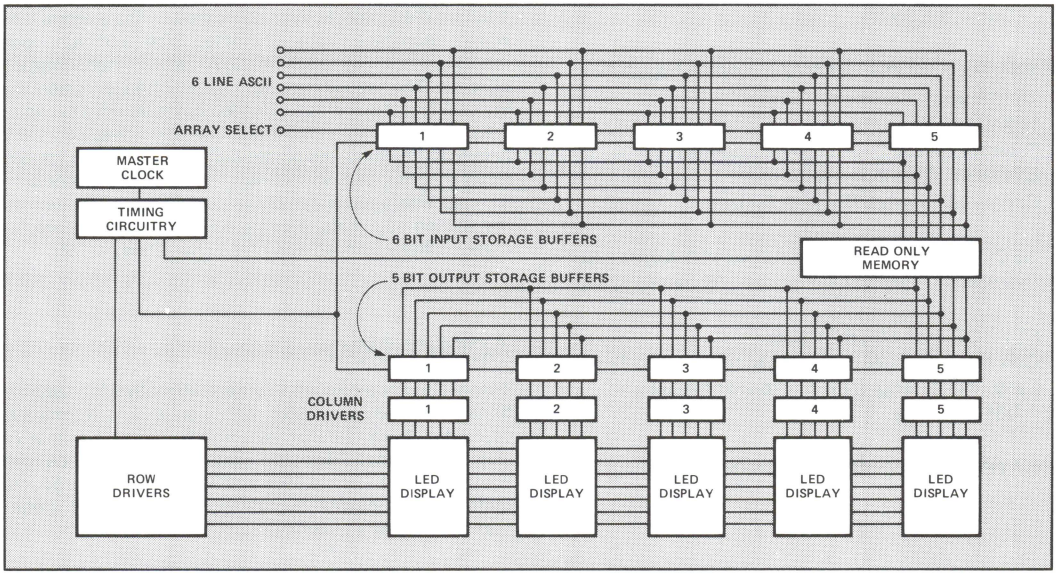


Figure 5. Row Scanning Block Diagram.

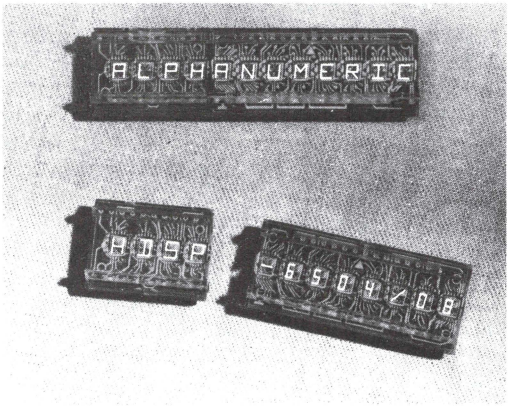
HEWLETT PACKARD

16 SEGMENT SOLID STATE ALPHANUMERIC DISPLAY

HDSP-6504
HDSP-6508

Features

- **ALPHANUMERIC**
  Displays 64 Character ASCII Set and Special Characters
- **16 SEGMENT FONT PLUS CENTERED D.P. AND COLON**
- **3.81mm (0.150") CHARACTER HEIGHT**
- **APPLICATION FLEXIBILITY WITH PACKAGE DESIGN**
  4 and 8 Character Dual-In-Line Packages
  End Stackable-On Both Ends for 8 Character and On One End for 4 Character
  Sturdy Gold-Plated Leads on 2.54mm (0.100") Centers
  Environmentally Rugged Package
  Common Cathode Configuration
- **LOW POWER**
  As Low as 1.0-1.5mA Average Per Segment Depending on Peak Current Levels
- **EXCELLENT CHARACTER APPEARANCE**
  Continuous Segment Font
  High On/Off Contrast
  6.35mm (0.250") Character Spacing
  Excellent Character Alignment
  Excellent Readability at 2 Metres
- **SECONDARY BARREL MAGNIFIER AVAILABLE**
  Increases Character Height to 4.45 mm (0.175")
- **SUPPORT ELECTRONICS**
  Can Be Driven With ROM Decoders and Drivers
  Easy Interfacing With Microprocessors and LSI Circuitry
- **CATEGORIZED FOR LUMINOUS INTENSITY**



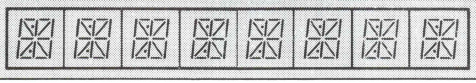
Description

The HDSP-6504 and HDSP-6508 are 3.81mm (0.150") sixteen segment GaAsP red alphanumeric displays mounted in 4 character and 8 character dual-in-line package configurations that permit mounting on PC boards or in standard IC sockets. The monolithic light emitting diode character is magnified by the integral lens which increases both character size and luminous intensity, thereby making low power consumption possible. The rugged package construction, enhanced by the backfill design, offers extended environmental capabilities compared to the standard PC board/lens type of display package. Its good temperature cycling capability is the result of the air gap which exists between the semiconductor chip/wire bond assembly and the lens. In addition to the sixteen segments, a centered D.P. and colon are included. Character spacing yields 4 characters per inch.

Applications

These alphanumeric displays are attractive for applications such as computer peripherals and terminals, computer base emergency mobile units, automotive instrument panels, desk top calculators, in-plant control equipment, hand-held instruments and other products requiring low power, display compactness and alphanumeric display capability.

Device Selection Guide

Characters Per Display	Configuration		Part No. HDSP-
	Device	Package	
4		(Figure 6)	6504
8		(Figure 7)	6508

Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Units
I_{PEAK}	Peak Forward Current Per Segment or DP (Duration ≤ 312μs)		200	mA
I_{AVG}	Average Current Per Segment or DP[1]		7	mA
P_D	Average Power Dissipation Per Character[1,2]		138	mW
T_A	Operating Temperature, Ambient	-40	85	°C
T_S	Storage Temperature	-40	100	°C
V_R	Reverse Voltage		5	V
	Solder Temperature at 1.59mm (1/16 inch) below seating plane, t ≤ 3 Seconds		260	°C

NOTES:
1. Maximum allowed drive conditions for strobed operation are derived from Figures 1 and 2. See electrical section of operational considerations.
2. Derate linearly above T_A = 50°C at 2.17mW/°C. P_D Max. (T_A = 85°C) = 62mW.

Electrical/Optical Characteristics at T_A=25°C

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
I_V	Luminous Intensity, Time Average, Character Total with 16 Segments Illuminated [3,4]	I_{PEAK} = 30mA 1/16 Duty Factor	0.40	1.65		mcd
V_F	Forward Voltage Per Segment or DP	I_F = 30mA (One Segment On)		1.6	1.9	V
λ_{PEAK}	Peak Wavelength			655		nm
λ_d	Dominant Wavelength [5]			640		nm
I_R	Reverse Current Per Segment or DP	V_R = 5V		10		μA
$\Delta V_F/\Delta°C$	Temperature Coefficient of Forward Voltage			-2		mV/°C
$R\theta_{J-PIN}$	Thermal Resistance LED Junction-to-Pin			232		°C/W/ Seg

NOTES:
3. The luminous intensity ratio between segments within a digit is designed so that each segment will have the same luminous sterance. Thus each segment will appear with equal brightness to the eye.
4. Each character of the display is matched for luminous intensity at the test conditions shown. Operation of the display at lower peak currents may cause intensity mismatch within the display. Operation at peak currents less than 7 mA will cause objectionable display segment matching.
5. The dominant wavelength, λd, is derived from the C.I.E. chromaticity diagram and represents that single wavelength which defines the color of the device, standard red.

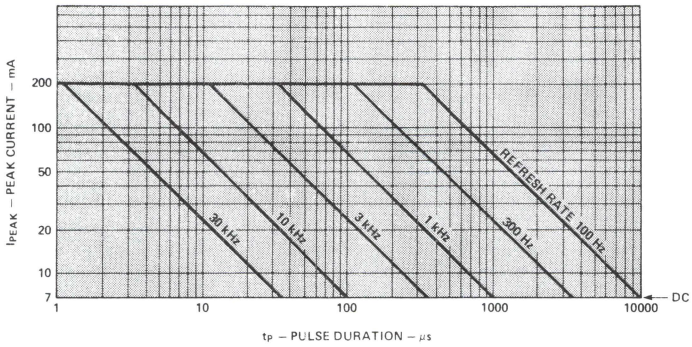


Figure 1. Maximum Allowed Peak Current vs. Pulse Duration. Derate derived operating conditions above $T_A = 50°C$ using Figure 2.

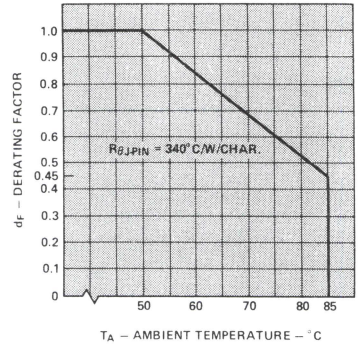


Figure 2. Temperature Derating Factor For Peak Current per Segment vs. Ambient Temperature. $T_J MAX = 110°C$

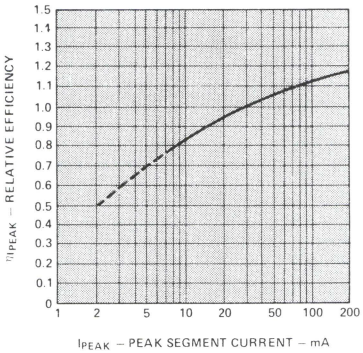


Figure 3. Relative Luminous Efficiency (Luminous Intensity Per Unit Current) vs. Peak Segment Current.

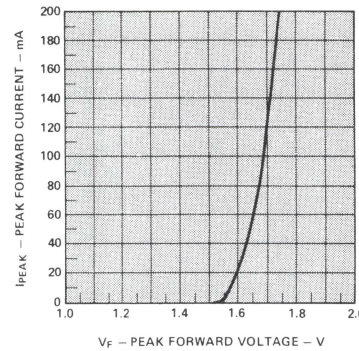


Figure 4. Peak Forward Segment Current vs. Peak Forward Voltage.

For a Detailed Explanation on the Use of Data Sheet Information and Recommended Soldering Procedures, See Application Note 1005.

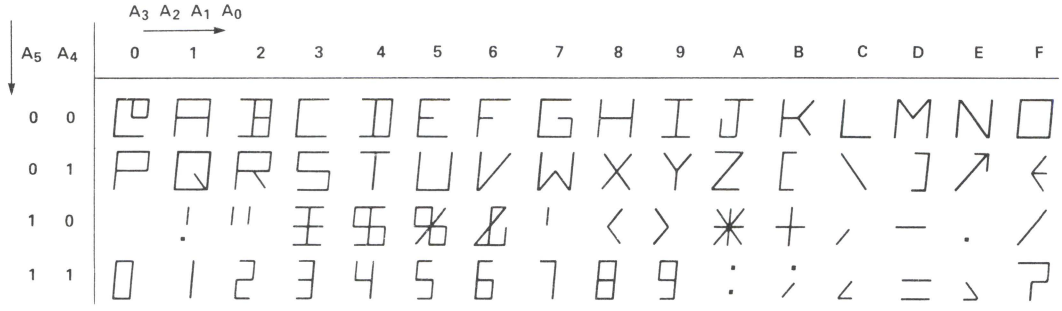


Figure 5. Typical 64 Character ASCII Set.

Additional Character Font

Package Dimensions

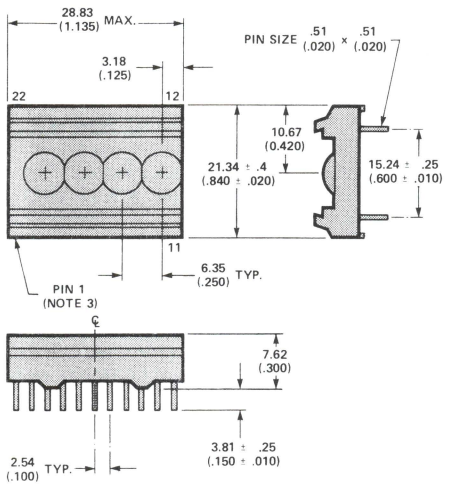


Figure 6. HDSP-6504

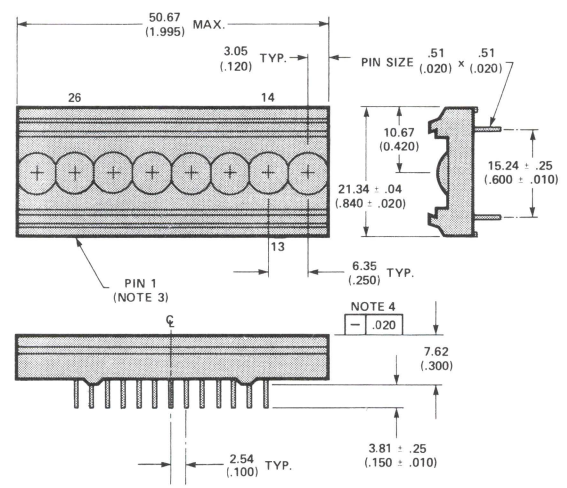


Figure 7. HDSP-6508

NOTES:
1. ALL DIMENSIONS IN MILLIMETRES AND (INCHES).
2. ALL UNTOLERANCED DIMENSIONS ARE FOR REFERENCE ONLY.
3. PIN 1 IDENTIFIED BY INK DOT ADJACENT TO LEAD.

Magnified Character Font Description

DEVICES
HDSP-6504
HDSP-6508

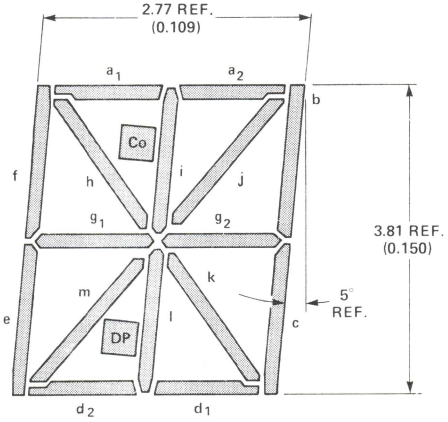


Figure 8.

Device Pin Description

Pin No.	Function			
	HDSP-6504		HDSP-6508	
1	Anode	Segment g_1	Anode	Segment g_1
2	Anode	Segment DP	Anode	Segment DP
3	Cathode	Digit 1	Cathode	Digit 1
4	Anode	Segment d_2	Anode	Segment d_2
5	Anode	Segment l	Anode	Segment l
6	Cathode	Digit 3	Cathode	Digit 3
7	Anode	Segment e	Anode	Segment e
8	Anode	Segment m	Anode	Segment m
9	Anode	Segment k	Anode	Segment k
10	Cathode	Digit 4	Cathode	Digit 4
11	Anode	Segment d_1	Anode	Segment d_1
12	Anode	Segment j	Cathode	Digit 6
13	Anode	Segment C_o	Cathode	Digit 8
14	Anode	Segment g_2	Cathode	Digit 7
15	Anode	Segment a_2	Cathode	Digit 5
16	Anode	Segment i	Anode	Segment j
17	Cathode	Digit 2	Anode	Segment C_o
18	Anode	Segment b	Anode	Segment g_2
19	Anode	Segment a_1	Anode	Segment a_2
20	Anode	Segment c	Anode	Segment i
21	Anode	Segment h	Cathode	Digit 2
22	Anode	Segment f	Anode	Segment b
23			Anode	Segment a_1
24			Anode	Segment c
25			Anode	Segment h
26			Anode	Segment f

Operational Considerations

ELECTRICAL

The HDSP-6504 and -6508 devices utilize large monolithic 16 segment GaAsP LED chips with centered decimal point and colon. Like segments of each digit are electrically interconnected to form an 18 by N array, where N is the quantity of characters in the display. In the driving scheme the decimal point or colon is treated as a separate character with its own time frame.

These displays are designed specifically for strobed (multiplexed) operation. Under normal operating situations the maximum number of illuminated segments needed to represent a given character is 10. Therefore, except where noted, the information presented in this data sheet is for a maximum of 10 segments illuminated per character.*

The typical forward voltage values, scaled from Figure 4, should be used for calculating the current limiting resistor values and typical power dissipation. Expected maximum V_F values for the purpose of driver circuit design may be calculated using the following V_F model:

$V_F = 1.85V + I_{PEAK}\ (1.8\Omega)$
For: $30mA \leq I_{PEAK} \leq 200mA$
$V_F = 1.58V + I_{PEAK}\ (10.7\Omega)$
For: $10mA \leq I_{PEAK} \leq 30mA$

OPTICAL AND CONTRAST ENHANCEMENT

Each large monolithic chip is positioned under a separate element of a plastic aspheric magnifying lens, producing a magnified character height of 3.81 mm (.150 inch). The aspheric lens provides wide included viewing angles of typically 75 degrees horizontal and 75 degrees vertical with low off-axis distortion. These two features, coupled with the very high segment luminous sterance, provide to the user a display with excellent readability in bright ambient light for viewing distances in the range of 2 meters. Effective contrast enhancement can be obtained by employing any of the following optical filter products: Panelgraphic: Ruby Red 60, Dark Red 63 or Purple 90; SGL Homalite: H100-1605 Red or H100-1804 Purple, Plexiglas 2423. For very bright ambients, such as indirect sunlight, the 3M Light Control Film is recommended: Red 655, Violet, Purple or Neutral Density.

For those applications requiring only 4 or 8 characters, a secondary barrel magnifier, HP part number HDSP-6505 (four character) and -6509 (eight character), may be inserted into support grooves on the primary magnifier. This secondary magnifier increases the character height to 4.45mm (.175 inch) without loss of horizontal viewing angle.

MECHANICAL

These devices are constructed by LED die attaching and wire bonding to a high temperature PC board substrate. A precision molded plastic lens is attached to the PC board and the resulting assembly is backfilled with a sealing epoxy to form an environmentally sealed unit.

The four character and eight character devices can be end stacked to form a character string which is a multiple of a basic four character grouping. As an example, one -6504 and two -6508 devices will form a 20 character string. These devices may be soldered onto a printed circuit board or inserted into 24 and 28 pin DIP LSI sockets. The socket spacing must allow for device end stacking.

Suitable conditions for wave soldering depend upon the specific kind of equipment and procedure used. For more information, consult the local HP Sales Office or Hewlett-Package Components, Palo Alto, California.

*More than 10 segments may be illuminated in a given character, provided the maximum allowed character power dissipation, temperature derated, is not exceeded.

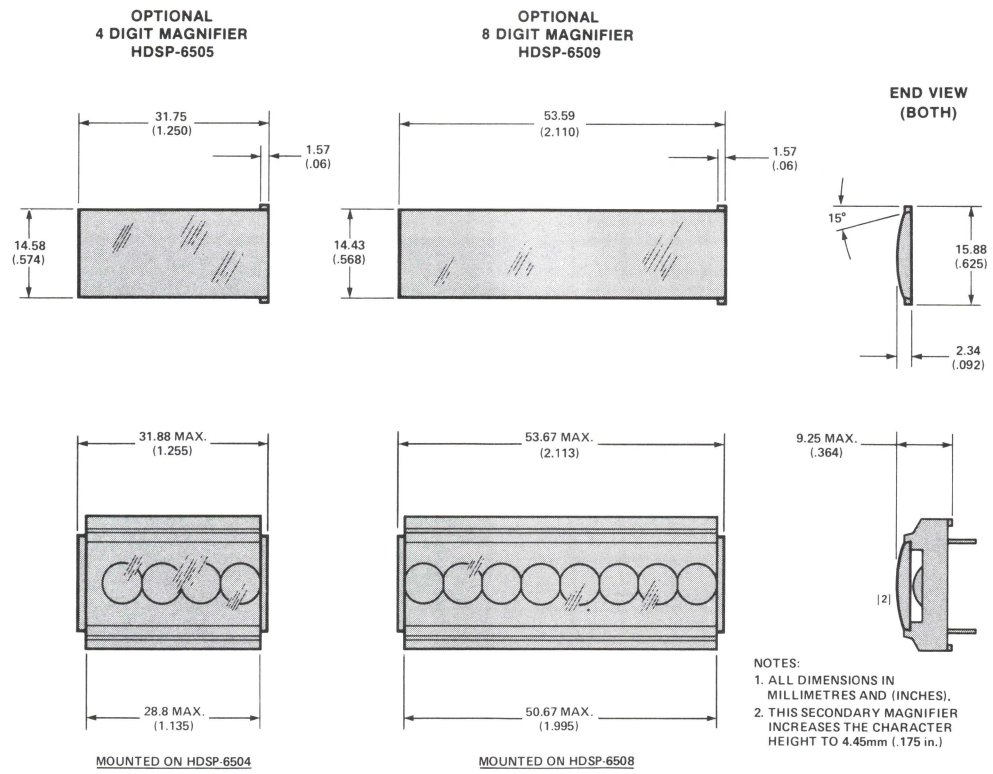


Figure 9. Design Data for Optional Barrel Magnifier in Single Display Applications.

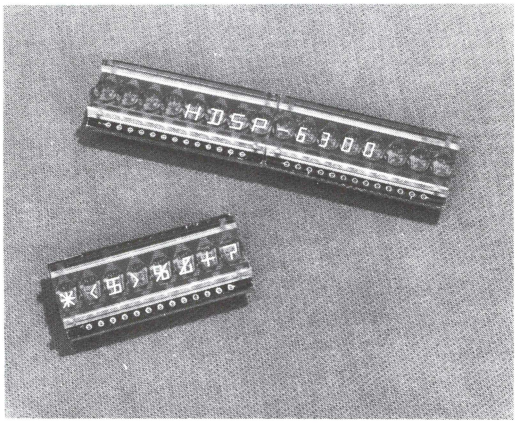
HEWLETT PACKARD

16 SEGMENT SOLID STATE ALPHANUMERIC DISPLAY

HDSP-6300

Features

- **ALPHANUMERIC**
  Displays 64 Character ASCII Set and Special Characters
- **16 SEGMENT FONT PLUS CENTERED D.P. AND COLON**
- **3.56mm (0.140") CHARACTER HEIGHT**
- **APPLICATION FLEXIBILITY WITH PACKAGE DESIGN**
  8 Character Dual-In-Line Package
  End Stackable
  Sturdy Leads on 2.54mm (0.100") Centers
  Common Cathode Configuration
- **LOW POWER**
  As Low as 1.0-1.5mA Average Per Segment Depending on Peak Current Levels
- **EXCELLENT CHARACTER APPEARANCE**
  Continuous Segment Font
  High On/Off Contrast
  5.08mm (0.200") Character Spacing
  Excellent Character Alignment
  Excellent Readability at 1.5 Metres
- **SUPPORT ELECTRONICS**
  Can Be Driven With ROM Decoders and Drivers
  Easy Interfacing With Microprocessors and LSI Circuitry
- **CATEGORIZED FOR LUMINOUS INTENSITY**



Description

The HDSP-6300 is a sixteen segment GaAsP red alphanumeric display mounted in an 8 character dual-in-line package configuration that permits mounting on PC boards or in standard IC sockets. The monolithic light emitting diode character is magnified by the integral lens which increases both character size and luminous intensity, thereby making low power consumption possible. The sixteen elements consist of sixteen segments for alphanumeric and special characters plus centered decimal point and colon for good visual aesthetics. Character spacing yields 5 characters per inch.

Applications

These alphanumeric displays are attractive for applications such as computer peripherals and mobile terminals, desk top calculators, in-plant control equipment, hand-held instruments and other products requiring low power, display compactness and alphanumeric display capability.

Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Units
I_{PEAK}	Peak Forward Current Per Segment or DP (Duration ≤ 417μs)		150	mA
I_{AVG}	Average Current Per Segment or DP[1]		6.25	mA
P_D	Average Power Dissipation Per Character[1,2]		133	mW
T_A	Operating Temperature, Ambient	-40	85	°C
T_S	Storage Temperature	-40	100	°C
V_R	Reverse Voltage		5	V
	Solder Temperature at 1.59mm (1/16 inch) below seating plane, t ≤ 5 Seconds		260	°C

NOTES:
1. Maximum allowed drive conditions for strobed operation are derived from Figures 1 and 2. See electrical section of operational considerations.
2. Derate linearly above T_A = 50°C at 2.47 mW/°C. P_D Max. (T_A = 85°C) = 47 mW.

Electrical/Optical Characteristics at T_A=25°C

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
I_V	Luminous Intensity, Time Average, Character Total with 16 Segments Illuminated [3,4]	I_{PEAK} = 24mA 1/16 Duty Factor	400	1200		μcd
V_F	Forward Voltage Per Segment or DP	I_F = 24mA (One Segment On)		1.6	1.9	V
λ_{PEAK}	Peak Wavelength			655		nm
λ_d	Dominant Wavelength [5]			640		nm
I_R	Reverse Current Per Segment or DP	V_R = 5V		10		μA
$R\theta_{J-PIN}$	Thermal Resistance LED Junction-to-Pin per Character			250		°C/W/ Char.

NOTES:
3. The luminous intensity ratio between segments within a digit is designed so that each segment will have the same luminous sterance. Thus each segment will appear with equal brightness to the eye.
4. Each character of the display is matched for luminous intensity at the test conditions shown. Operation of the display at lower peak currents may cause intensity mismatch within the display. Operation at peak currents less than 7 mA will cause objectionable display segment matching.
5. The dominant wavelength, λd, is derived from the C.I.E. chromaticity diagram and represents that single wavelength which defines the color of the device, standard red.

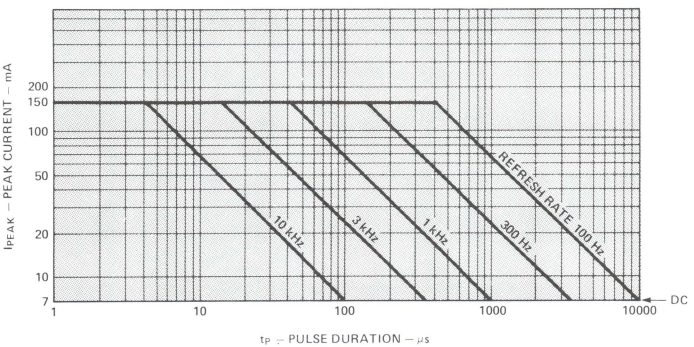


Figure 1. Maximum Allowed Peak Current vs. Pulse Duration. Derate derived operating conditions above T_A = 50°C using Figure 2.

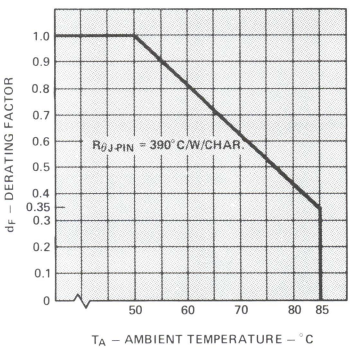


Figure 2. Temperature Derating Factor For Peak Current per Segment vs. Ambient Temperature. T_JMAX = 110°C

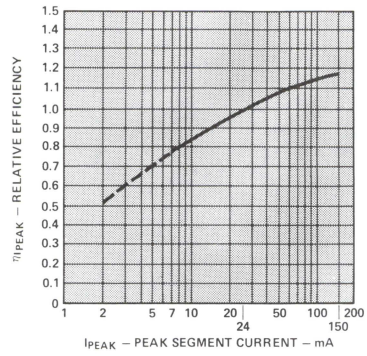


Figure 3. Relative Luminous Efficiency (Luminous Intensity Per Unit Current) vs. Peak Segment Current.

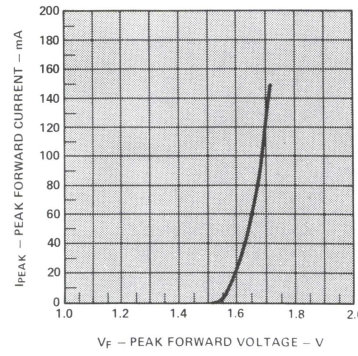


Figure 4. Peak Forward Segment Current vs. Peak Forward Voltage.

For a Detailed Explanation on the Use of Data Sheet Information and Recommended Soldering Procedures, See Application Note 1005.

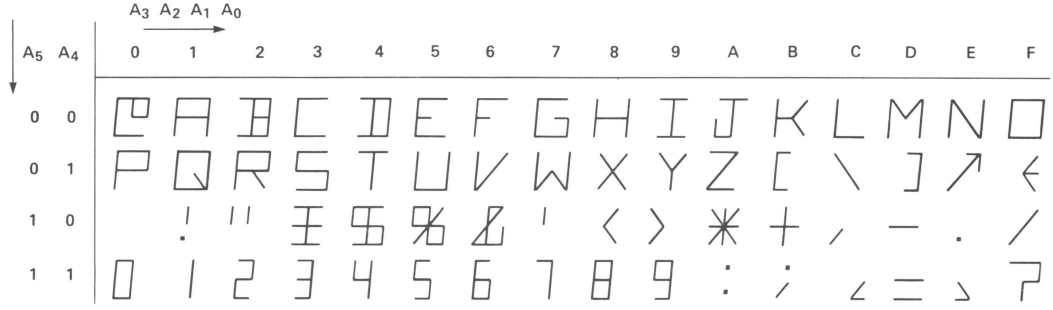
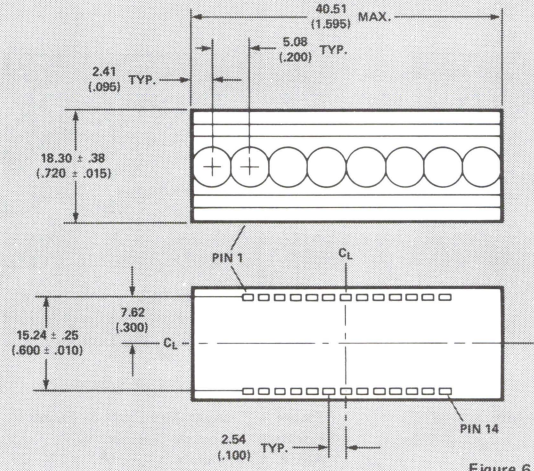
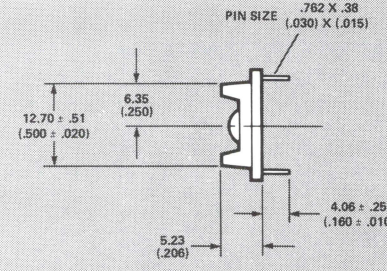


Figure 5. Typical 64 Character ASCII Set.

Additional Character Font





NOTES:
1. ALL DIMENSIONS IN MILLIMETRES AND (INCHES).
2. ALL UNTOLERANCED DIMENSIONS ARE FOR REFERENCE ONLY.
3. PIN 1 IDENTIFIED BY DOT ADJACENT TO LEAD.

Figure 6.

Magnified Character Font Description

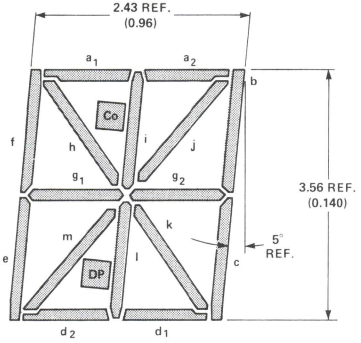


Figure 7.

Device Pin Description

Pin No.	Function	
1	Anode	Segment K
2	Anode	Segment D_1
3	Anode	Segment C
4	Cathode	Digit 1
5	Cathode	Digit 2
6	Cathode	Digit 3
7	Cathode	Digit 4
8	Anode	Segment L
9	Anode	Segment G_2
10	Anode	Segment E
11	Anode	Segment M
12	Anode	Segment D_2
13	Anode	Segment DP
14	Anode	Segment A_2
15	Anode	Segment I
16	Anode	Segment J
17	Cathode	Digit 8
18	Cathode	Digit 7
19	Cathode	Digit 6
20	Cathode	Digit 5
21	Anode	Segment C_o
22	Anode	Segment G_1
23	Anode	Segment B
24	Anode	Segment F
25	Anode	Segment H
26	Anode	Segment A_1

Operational Considerations

ELECTRICAL

The HDSP-6300 device utilizes large monolithic 16 segment plus centered decimal point and colon GaAsP LED chips. Like segments of each digit are electrically interconnected to form an 18 by N array, where N is the quantity of characters in the display. In the driving scheme the decimal point or colon is treated as a separate character with its own time frame.

This display is designed specifically for strobed (multiplexed) operation. Under normal operating situations the maximum number of illuminated segments needed to represent a given character is 10. Therefore, except where noted, the information presented in this data sheet is for a maximum of 10 segments illuminated per character.*

The typical forward voltage values, scaled from Figure 4, should be used for calculating the current limiting resistor values and typical power dissipation. Expected maximum V_F values for the purpose of driver circuit design may be calculated using the following V_F model:

$V_F = 1.85V + I_{PEAK}\ (1.8\Omega)$
For $30mA \leq I_{PEAK} \leq 150mA$
$V_F = 1.58V + I_{PEAK}\ (10.7\Omega)$
For $10mA \leq I_{PEAK} \leq 30mA$

*More than 10 segments may be illuminated in a given character, provided the maximum allowed character power dissipation, temperature derated, is not exceeded.

OPTICAL AND CONTRAST ENHANCEMENT

Each large monolithic chip is positioned under a separate element of a plastic aspheric magnifying lens producing a magnified character height of 3.56mm (0.140 inch). The aspheric lens provides wide included viewing angles of 60 degrees horizontal and 55 degrees vertical with low off axis distortion. These two features, coupled with the very high segment luminous sterance, provide to the user a display with excellent readability in bright ambient light for viewing distances in the range of 1.5 metres. Effective contrast enhancement can be obtained by employing an optical filter product such as Panelgraphic Ruby Red 60, Dark Red 63 or Purple 90; SGL Homalite H100-1605 Red or H100-1804 Purple; or Plexiglas 2423. For very bright ambients, such as indirect sunlight, the 3M Red 655 or Neutral Density Light Control Film is recommended.

MECHANICAL

This device is constructed by LED die attaching and wire bonding to a high temperature PC board substrate. A precision molded plastic lens is attached to the PC board.

The HDSP-6300 can be end stacked to form a character string which is a multiple of a basic eight character grouping. These devices may be soldered onto a printed circuit board or inserted into 28 pin DIP LSI sockets. The socket spacing must allow for device end stacking.

Suitable conditions for wave soldering depend upon the specific kind of equipment and procedure used. It is recommended that a non-activated rosin core wire solder or a low temperature deactivating flux and solid wire solder be used in soldering operations. For more information, consult the local HP Sales Office or Hewlett-Packard Components, Palo Alto, California.

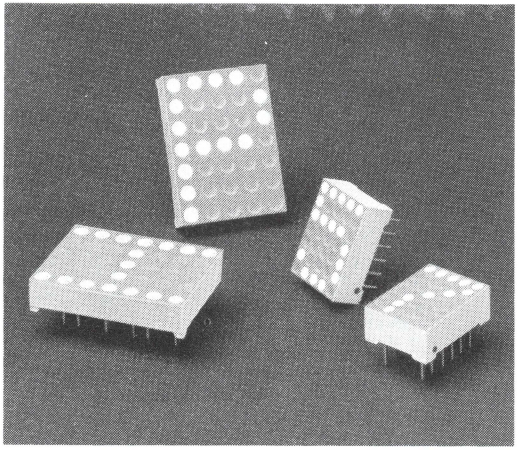
HEWLETT PACKARD

LARGE 5 x 7 DOT MATRIX ALPHANUMERIC DISPLAYS

17.3 mm (0.68 in.) STANDARD RED HDSP-4701/4703
26.5 mm (1.04 in.) STANDARD RED HDSP-4401/4403
26.5 mm (1.04 in.) HIGH EFFICIENCY RED HDSP-4501/4503

Features

- LARGE CHARACTER HEIGHTS
- 5 x 7 DOT MATRIX FONT
- VIEWABLE UP TO 18 METERS (1.04 in. DISPLAY)
- X-Y STACKABLE
- IDEAL FOR GRAPHICS PANELS
- AVAILABLE IN COMMON ROW ANODE AND COMMON ROW CATHODE CONFIGURATIONS
- CATEGORIZED FOR INTENSITY
- MECHANICALLY RUGGED
- AVAILABLE IN CUSTOM DISPLAY BOARDS



Description

The large 5 x 7 dot matrix alphanumeric display family is comprised of 26.5 mm (1.04 inch) character height packages (HDSP-440X Standard Red, and HDSP-450X High Efficiency Red) and 17.3 mm (0.68 inch) packages (HDSP-470X Standard Red). These devices have excellent viewability; the 1.04 inch character font can be read at up to 18 metres (12 metres for the 0.68 inch device).

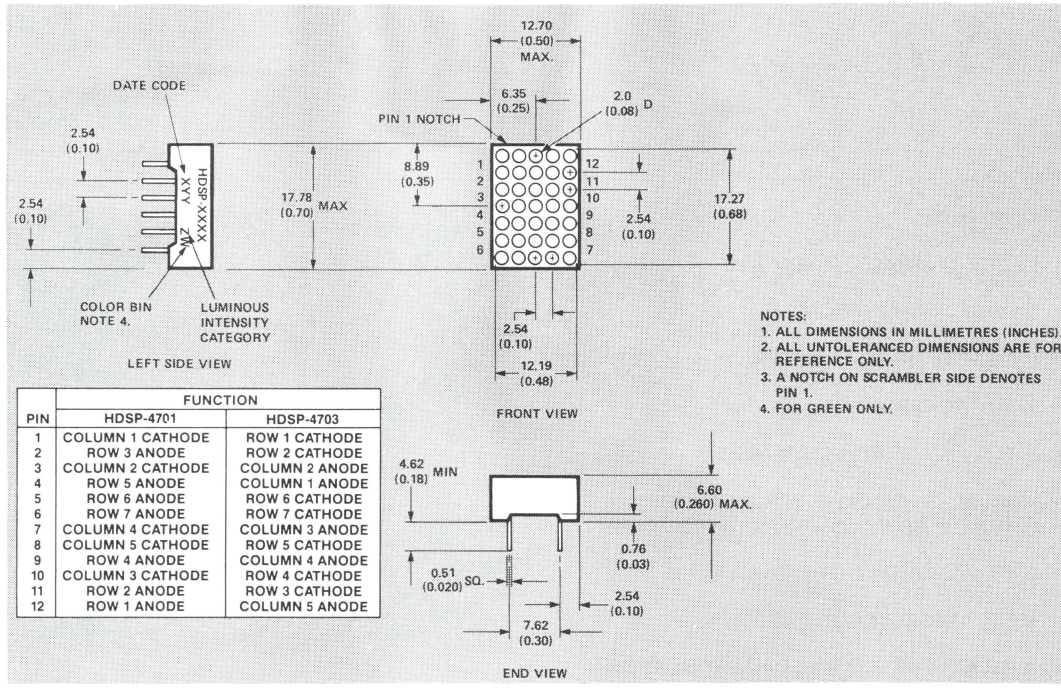
These devices utilize a 10.2 mm (0.4 inch) dual-in-line (DIP) configuration for the 1.04 inch font, while the 0.68 inch font has an industry standard 7.6 mm (0.3 inch) DIP configuration.

Applications include electronic instrumentation, computer peripherals, point of sale terminals, weighing scales, and industrial electronics.

Devices

Part Number	Color	Description
HDSP-4701 HDSP-4703	Standard Red	17.3 mm Common Row Anode 17.3 mm Common Row Cathode
HDSP-4401 HDSP-4403	Standard Red	26.5 mm Common Row Anode 26.5 mm Common Row Cathode
HDSP-4501 HDSP-4503	High Efficiency Red	26.5 mm Common Row Anode 26.5 mm Common Row Cathode

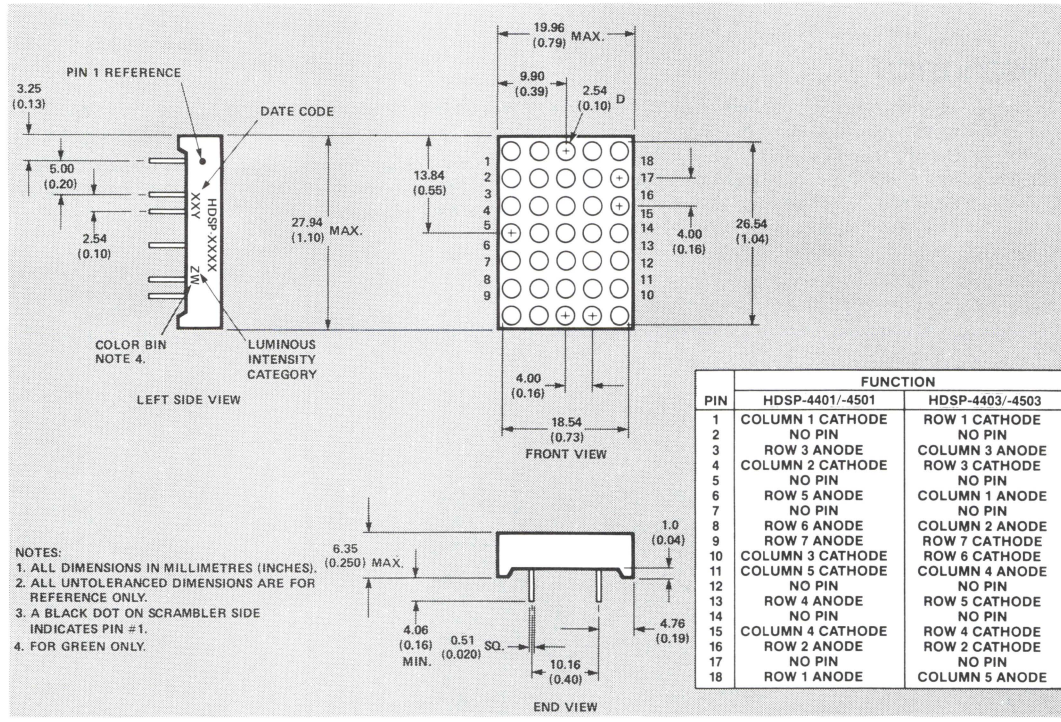
Package Dimensions (HDSP-470X Series)



NOTES:
1. ALL DIMENSIONS IN MILLIMETRES (INCHES).
2. ALL UNTOLERANCED DIMENSIONS ARE FOR REFERENCE ONLY.
3. A NOTCH ON SCRAMBLER SIDE DENOTES PIN 1.
4. FOR GREEN ONLY.

PIN	FUNCTION	
	HDSP-4701	HDSP-4703
1	COLUMN 1 CATHODE	ROW 1 CATHODE
2	ROW 3 ANODE	ROW 2 CATHODE
3	COLUMN 2 CATHODE	COLUMN 2 ANODE
4	ROW 5 ANODE	COLUMN 1 ANODE
5	ROW 6 ANODE	ROW 6 CATHODE
6	ROW 7 ANODE	ROW 7 CATHODE
7	COLUMN 4 CATHODE	COLUMN 3 ANODE
8	COLUMN 5 CATHODE	ROW 5 CATHODE
9	ROW 4 ANODE	COLUMN 4 ANODE
10	COLUMN 3 CATHODE	ROW 4 CATHODE
11	ROW 2 ANODE	ROW 3 CATHODE
12	ROW 1 ANODE	COLUMN 5 ANODE

Package Dimensions (HDSP-440X/-450X/Series)

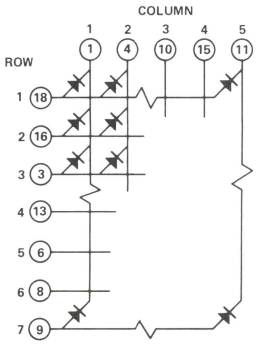


NOTES:
1. ALL DIMENSIONS IN MILLIMETRES (INCHES).
2. ALL UNTOLERANCED DIMENSIONS ARE FOR REFERENCE ONLY.
3. A BLACK DOT ON SCRAMBLER SIDE INDICATES PIN #1.
4. FOR GREEN ONLY.

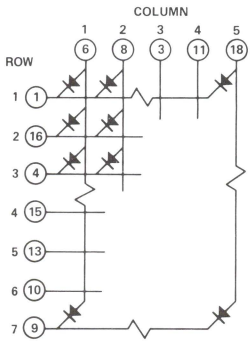
PIN	FUNCTION	
	HDSP-4401/-4501	HDSP-4403/-4503
1	COLUMN 1 CATHODE	ROW 1 CATHODE
2	NO PIN	NO PIN
3	ROW 3 ANODE	COLUMN 3 ANODE
4	COLUMN 2 CATHODE	ROW 3 CATHODE
5	NO PIN	NO PIN
6	ROW 5 ANODE	COLUMN 1 ANODE
7	NO PIN	NO PIN
8	ROW 6 ANODE	COLUMN 2 ANODE
9	ROW 7 ANODE	ROW 7 CATHODE
10	COLUMN 3 CATHODE	ROW 6 CATHODE
11	COLUMN 5 CATHODE	COLUMN 4 ANODE
12	NO PIN	NO PIN
13	ROW 4 ANODE	ROW 5 CATHODE
14	NO PIN	NO PIN
15	COLUMN 4 CATHODE	ROW 4 CATHODE
16	ROW 2 ANODE	ROW 2 CATHODE
17	NO PIN	NO PIN
18	ROW 1 ANODE	COLUMN 5 ANODE

Internal Circuit Diagrams

HDSP-4401/4501/ COMMON ANODE ROW

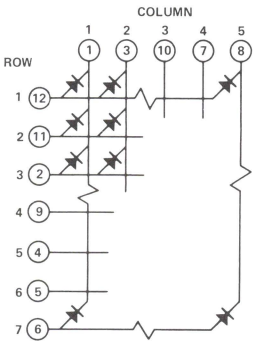


HDSP-4403/4503/ COMMON CATHODE ROW

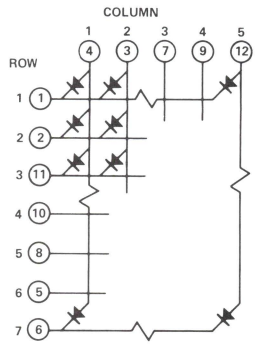


X = ROW OR COLUMN NUMBER, (X) = PIN NUMBER

HDSP-4701/ COMMON ANODE ROW



HDSP-4703/ COMMON CATHODE ROW



X = ROW OR COLUMN NUMBER, (X) = PIN NUMBER

Absolute Maximum Ratings at 25°C

	HDSP-450X Series	HDSP-440X Series HDSP-470X Series
Average Power per Dot (T_A = 25° C)[1]	75 mW	75 mW
Peak Forward Current per Dot (T_A = 25° C)[2]	90 mA	125 mA
Average Forward Current per Dot (T_A = 25° C)[3]	15 mA	25 mA
Operating Temperature Range	-40° C to +85° C	
Storage Temperature Range	-40° C to +85° C	
Reverse Voltage per Dot	3.0 V	
Lead Solder Temperature (1.59 mm [1/16 inch] below seating plane)	260° C for 3 sec.	

Notes:
1. Average power is based on 20 dots 'on' per character. Total package power dissipation should not exceed 1.5 W.
2. Do not exceed maximum average current per dot.
3. For the HDSP-440X series and HDSP-470X series displays, derate maximum average current above 50° C at 0.4 mA/° C. For the HDSP-450X series displays, derate maximum average current above 35° C at 0.2 mA/° C. This derating is based on a device mounted in a socket having a thermal resistance from junction to ambient of 1000° C/W per dot.

Electrical/Optical Characteristics at T_A = 25°C

STANDARD RED HDSP-470X SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Dot[4] (Digit Average)	I_V	100 mA Pk: 1 of 5 Duty Factor (20 mA Avg.)	360	770		μcd
Peak Wavelength	λ_{PEAK}			655		nm
Dominant Wavelength[5]	λ_D			640		nm
Forward Voltage/Dot	V_F	I_F = 100 mA		1.8	2.2	V
Reverse Voltage/Dot or DP[6]	V_R	I_R = 100 μA	3.0	12		V
Temperature Coefficient of V_F/Dot	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin per Dot	$R\phi_{J\text{-}PIN}$			420		° C/W/ Dot

STANDARD RED HDSP-440X SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Dot[4] (Digit Average)	I_V	100 mA Pk: 1 of 5 Duty Factor (20 mA Avg.)	400	860		μcd
Peak Wavelength	λ_{PEAK}			655		nm
Dominant Wavelength[5]	λ_D			640		nm
Forward Voltage/Dot	V_F	I_F = 100 mA		1.8	2.2	V
Reverse Voltage/Dot or DP[6]	V_R	I_R = 100 μA	3.0	12		V
Temperature Coefficient of V_F/Dot	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin per Dot	$R\phi_{J\text{-}PIN}$			380		° C/W/ Dot

HIGH EFFICIENCY RED HDSP-450X SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Dot[4] (Digit Average)	I_V	50 mA Pk: 1 of 5 Duty Factor (10 mA Avg.)	1400	3500		μcd
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength[5]	λ_D			626		nm
Forward Voltage/Dot	V_F	I_F = 50 mA		2.6	3.5	V
Reverse Voltage/Dot or DP[6]	V_R	I_R = 100 μA	3.0	25.0		V
Temperature Coefficient of V_F/Dot	ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin per Dot	$R\phi_{J\text{-}PIN}$			380		° C/W/ Dot

Notes:

4. The displays are categorized for luminous intensity with the intensity category designated by a letter on the left hand side of the package. The luminous intensity minimum and categories are determined by computing the numerical average of the individual segment intensities.
5. The dominant wavelength is derived from the C.I.E. Chromaticity diagram and is that single wavelength which defines the color of the device.
6. Typical specification for reference only. Do not exceed absolute maximum ratings.
7. The displays are categorized as to dominant wavelength with the category designated by a number adjacent to the intensity category letter.

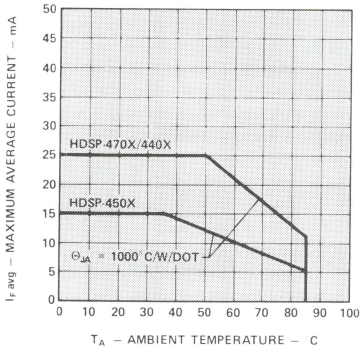


Figure 1. Maximum Allowable Average Current Per Dot as a Function of Ambient Temperature

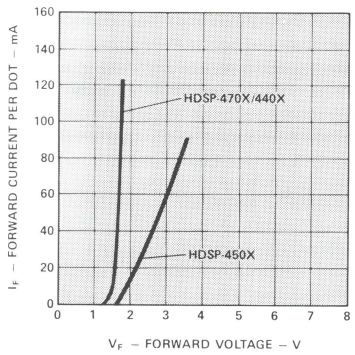


Figure 2. Forward Current vs. Forward Voltage HDSP-440X/470X, HDSP-450X

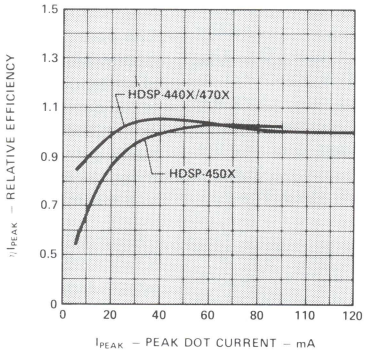


Figure 3. Relative Efficiency (Luminous Intensity Per Unit Dot) vs. Peak Current per Dot

Operational Considerations

ELECTRICAL

Circuit Design

These display devices are composed of light emitting diodes, with the light from each LED optically stretched to form individual dots.

These display devices are well suited for strobed operation. The typical forward voltage values, scaled from Figure 2, should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F MAX models:

HDSP-440X/-470X Series: $V_F = 1.55\ V + I_{PEAK}\ (6.5\ \Omega)$
For $5\ mA \leq I_{PEAK} \leq 125\ mA$

HDSP-450X Series: $V_F\ MAX = 1.75\ V + I_{PEAK}\ (35\ \Omega)$
For $I_{PEAK} \geq 5\ mA$

The Coded Data Controller circuit, shown in Figure 4, is designed to display eight characters of ASCII text. ASCII coded data is stored in a local 128 x 8 RAM. After the

microprocessor has loaded the RAM, local scanning circuitry controls the decoding of the ASCII, the display data loading and the display row select function. With minor modifications the circuit can be utilized for up to 128 display characters. The RAM used in this circuit is an MCM6810P with the address and data inputs isolated with tristate buffers. This allows the RAM to be accessed either by the microprocessor or by the local scanning electronics. The protocol is arranged such that the microprocessor always takes precedence over the local scanning electronics.

The Motorola 6810 RAM stores 8 bytes of ASCII data which is continuously read, decoded and displayed. The ASCII data from the RAM is decoded by the Motorola 6674 128 character ASCII decoder. The 6674 decoder has five column outputs which are gated to the Sprague UCN5832A 32 bit shift register data input via a 74LS151 multiplexer. Strobing of the display is accomplished via the 74LS90, 74LS393 and 74LS197 counter string.

The 74LS197 is used as a divide by 7 counter. Output Q_D resets the counter and loads output Q_A to logic 1 and outputs Q_B, Q_C and Q_D to logic 0. Outputs Q_A, Q_B, and Q_C of the 74LS197 are used to synchronize the row drivers and the row data entry into the shift register. Row drivers are sequentially turned on and off so that only one row driver is on at a given time.

The 74LS393 counter is used as a divide by 64 counter. This counter has two functions. The first is to provide the address of the character to be decoded. Outputs $1Q_A$, $1Q_B$, and $1Q_C$ supply the address to the RAM. The other function is to generate a signal which will simultaneously clock the 74LS197, disable the row drivers and shift register outputs, and provide one of the logic signals needed to enable the system clock to clock data into the shift register. Outputs $1Q_D$, $2Q_A$, and $2Q_B$ are gated to create this signal. The duty factor for this system is 1 of 8 or 12.5%.

The 74LS90 is connected as a divide by 5 cascaded into a divide by 2 for an effective divide by 10 counter. Outputs Q_B, Q_C, and Q_D are used to convert the parallel output from the character generator to serial input for entry into the shift register. Output Q_A in combination with the system clock and the gated outputs of the 74LS393 counter are used to clock data into the shift register. When character data is loaded into the shift register, output Q_A alternates between allowing data to be loaded and providing setup time for a valid address at the RAM to generate valid decoded character data at the output of the 74LS151 multiplexer.

This circuit can be used with the HDSP-4701 with minor modifications due to different pin locations. HDSP-4X03 devices require a change of both the shift register and drive transistors. The shift register can be changed to a Sprague UCN-5818. This part has different pin assignments than the UCN-5832. For further details consult the Sprague data sheet. The MJE700 Darlington transistors need to be replaced with suitable npn Darlington transistors.

THERMAL CONSIDERATIONS

The thermal resistance of the device may be used to calculate the junction temperature of the central LED. Equation 1 is used to calculate the junction temperature of the central (hottest) LED.

$$T_j = P_D \times \Theta_{j\text{-}a} + T_A \quad (1)$$

$$P_D = V_{F(max)} \times I_{F(avg)} \quad (2)$$

$$\Theta_{j\text{-}a} = \Theta_{j\text{-}pin} + \Theta_{pin\text{-}a} \quad (3)$$

T_j is the junction temperature of the central LED.
T_A is the ambient temperature.
$\Theta_{j\text{-}a}$ is the thermal resistance from the central LED to the ambient.
$\Theta_{pin\text{-}a}$ is the thermal resistance from the case (any pin) to the ambient.
$\Theta_{j\text{-}pin}$ is the thermal resistance of the device.
$V_{F(max)}$ is calculated using the appropriate V_F model.
P_D is the power dissipated by one LED.

The junction temperature of the central LED was measured with all of the dots on at a fixed drive current. The thermal resistance was calculated by using equation 4.

$$\Theta_{j\text{-}pin} = (T_j - T_{pin})/P_D \quad (4)$$

Where T_{pin} is the temperature of the hottest pin.

CONTRAST ENHANCEMENT

The objective of contrast enhancement is to provide good display readability in the end use ambient light. The concept is to employ both luminance and chrominance contrast techniques to enhance the readability by having the OFF-dots blend into the display background and the ON-dots stand out vividly against this same background. Therefore, these display devices are assembled with a gray package and matching encapsulating epoxy in the dots.

Contrast enhancement may be achieved by using one of the following suggested filters:

HDSP-440X/-470X:
- Panelgraphic RUBY RED 60
- SGL Homalite H100-1605 RED
- 3M Louvered Filter R6610 RED or N0210 GRAY

HDSP-450X:
- Panelgraphic SCARLET RED 65 or GRAY 10
- SGL Homalite H100-1670 RED or H100 GRAY
- 3M Louvered Filter R6310 RED or N0210 GRAY

For further information on contrast enhancement please see Application Note 1015.

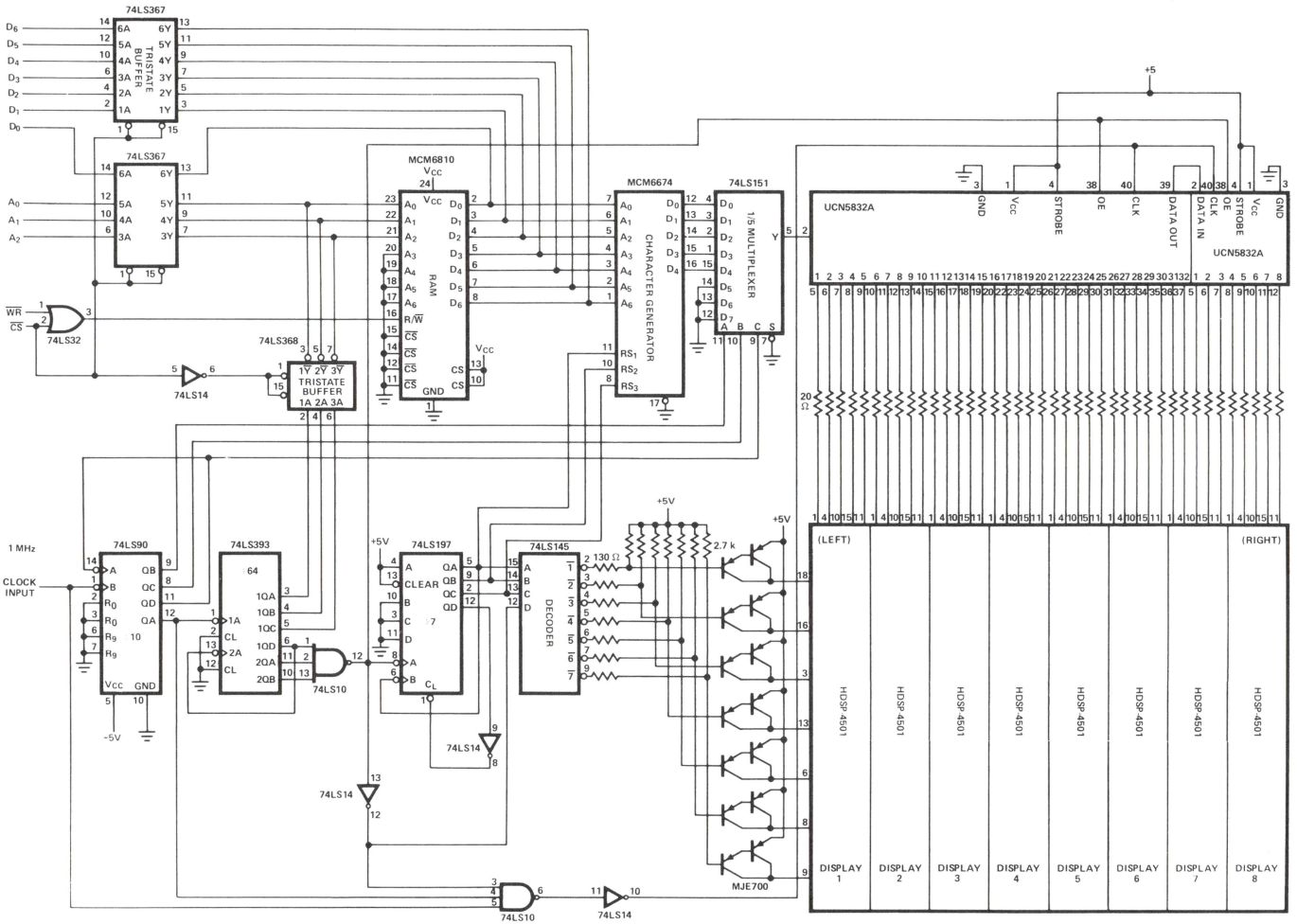


Figure 4. Coded Data Controller Circuit

MECHANICAL HANDLING

To optimize device optical performance, specially developed plastics are used which restrict the solvents which may be used for cleaning. It is recommended that only azeotropes of Freon (F113) and isopropanol and/or ethanol be used for vapor cleaning processes, with an immersion time in the vapors of less than 2 minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolve DES, DI-15 or DE-15, Arklone A or K. A 60° C (140° F) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and thorough air dry. Total exposure to hot water should not exceed 15 minutes. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, ethanol, isopropanol or water with a mild detergent.

Cleaning agents from the ketone family (acetone, methyl ethyl ketone, etc.) and from the chlorinated hydrocarbon family (methylene chloride, trichloroethylene, carbon tetrachloride, etc.) are not recommended for cleaning LED parts. All of these various solvents attack or dissolve the plastics and encapsulating epoxies used to form the packages of these LED devices.

For further information on soldering and cleaning please see Hewlett-Packard Application Note 1027.

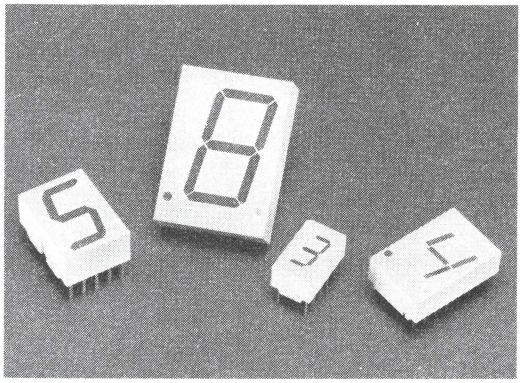
HEWLETT PACKARD

Double Heterojunction AlGaAs RED LOW CURRENT SEVEN SEGMENT DISPLAYS

7.6 mm (0.3 in)	HDSP-A101 SERIES
10.9 mm (0.43 in)	HDSP-E100 SERIES
14.2 mm (0.56 in)	HDSP-H101 SERIES
20.0 mm (0.8 in)	HDSP-N100 SERIES

Features

- **LOW POWER CONSUMPTION**
  Typical Power Consumption is 1.6 mW/Seg at 1 mA Drive
  Ideal for Battery Operated Applications
  Special Selection is Available for Operation at ½ mA
- **TYPICAL INTENSITY OF 650 μcd/Seg AT 1 mA DRIVE**
- **EXCELLENT FOR MULTIPLEXING LONG DIGIT STRINGS**
- **COMPATIBLE WITH MONOLITHIC LED DISPLAY DRIVERS**
- **FOUR CHARACTER SIZES**
  7.6 mm (0.3 in), 10.9 mm (0.43 in), 14.2 mm (0.56 in), 20.0 mm (0.8 in)
- **COMMON ANODE OR COMMON CATHODE**
  Overflow ±1 Character
- **EXCELLENT CHARACTER APPEARANCE**
  Wide Viewing Angle
  Grey Body for Optimum Contrast
- **CATEGORIZED FOR LUMINOUS INTENSITY**
  Use of Like Categories Yields a Uniform Display



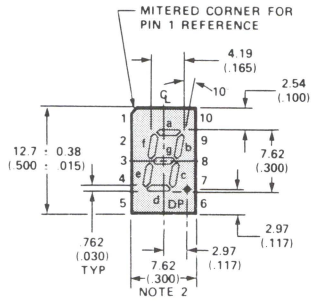
Description

This line of solid state LED displays uses newly developed Double Heterojunction (DH) AlGaAs/GaAs material to emit deep red light at 650 nm. This material has outstanding efficiency at low drive currents and can be either DC or pulse driven. Viewability at up to 10 metres (HDSP-N100 Series) is available for applications such as instruments, weighing scales, meters and point-of-sale terminals.

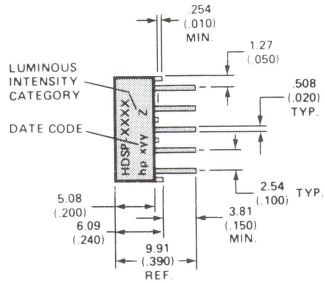
Devices

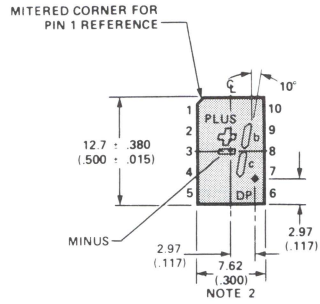
Part No. HDSP-	Character Size	Description	Package Drawing
A101	0.3" Mini (7.6 mm)	Common Anode Right Hand Decimal	A
A103		Common Cathode Right Hand Decimal	B
A107		Overflow ±1 Common Anode	C
A108		Overflow ±1 Common Cathode	D
E100	0.43" (10.9 mm)	Common Anode Left Hand Decimal	E
E101		Common Anode Right Hand Decimal	F
E103		Common Cathode Right Hand Decimal	G
E106		Universal Overflow ±1	H
H101	0.56" (14.2 mm)	Common Anode Right Hand Decimal	I
H103		Common Cathode Right Hand Decimal	J
H107		Overflow ±1 Common Anode	K
H108		Overflow ±1 Common Cathode	L
N100	0.8" (20 mm)	Common Anode Left Hand Decimal	M
N101		Common Anode Right Hand Decimal	N
N103		Common Cathode Right Hand Decimal	O
N105		Common Cathode Left Hand Decimal	P
N106		Universal Overflow ±1	Q

Package Dimensions (HDSP-A101 Series)

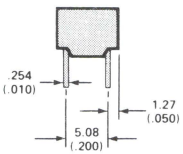


A, B





C, D

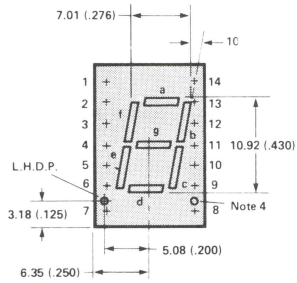


Notes:

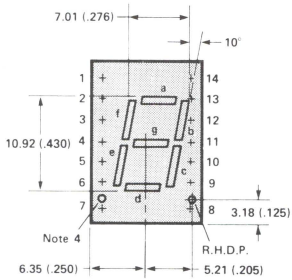
1. All dimensions in millimetres (inches).
2. Maximum.
3. All untoleranced dimensions are for reference only.
4. Redundant anodes.
5. Redundant cathodes.

PIN	FUNCTION			
	A	B	C	D
1	ANODE [4]	CATHODE [5]	ANODE [4]	CATHODE [5]
2	CATHODE f	ANODE f	CATHODE PLUS	ANODE PLUS
3	CATHODE g	ANODE g	CATHODE MINUS	ANODE MINUS
4	CATHODE e	ANODE e	NC	NC
5	CATHODE d	ANODE d	NC	NC
6	ANODE [4]	CATHODE [5]	ANODE [4]	CATHODE [5]
7	CATHODE DP	ANODE DP	CATHODE DP	ANODE DP
8	CATHODE c	ANODE c	CATHODE c	ANODE c
9	CATHODE b	ANODE b	CATHODE b	ANODE b
10	CATHODE a	ANODE a	NC	NC

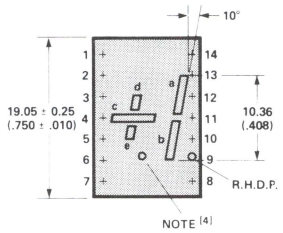
Package Dimensions (HDSP-E100 Series)



E

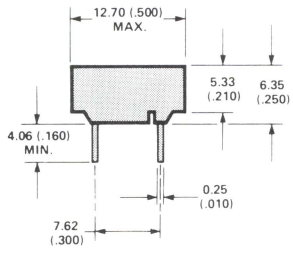


F, G

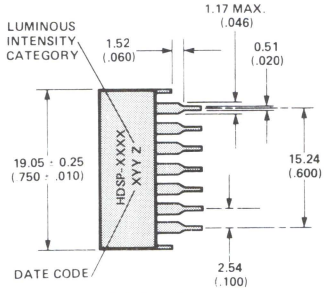


H

FRONT VIEW



END VIEW



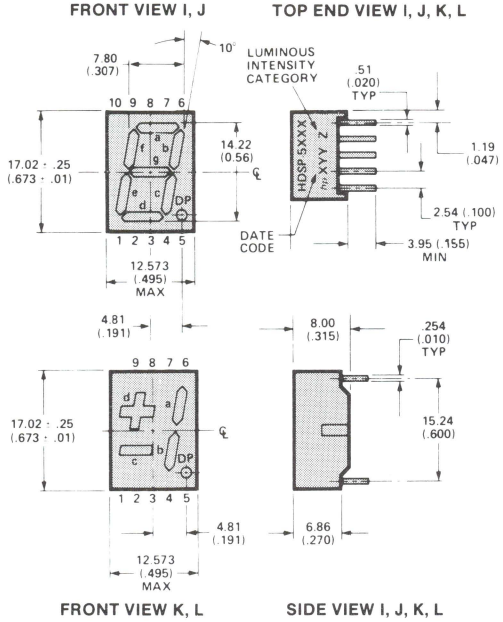
SIDE VIEW

PIN	FUNCTION			
	E	F	G	H
1	CATHODE a	CATHODE a	ANODE a	CATHODE d
2	CATHODE f	CATHODE f	ANODE f	ANODE d
3	ANODE [3]	ANODE [3]	CATHODE [6]	NO PIN
4	NO PIN	NO PIN	NO PIN	CATHODE c
5	NO PIN	NO PIN	NO PIN	CATHODE e
6	CATHODE dp	NO CONN. [5]	NO CONN. [5]	ANODE e
7	CATHODE e	CATHODE e	ANODE e	ANODE c
8	CATHODE d	CATHODE d	ANODE d	ANODE dp
9	NO CONN [5]	CATHODE dp	ANODE dp	CATHODE dp
10	CATHODE c	CATHODE c	ANODE c	CATHODE b
11	CATHODE g	CATHODE g	ANODE g	CATHODE a
12	NO PIN	NO PIN	NO PIN	NO PIN
13	CATHODE b	CATHODE b	ANODE b	ANODE a
14	ANODE [3]	ANODE [3]	CATHODE [6]	ANODE b

NOTES:

1. Dimensions in millimeters and (inches).
2. All untoleranced dimensions are for reference only.
3. Redundant anodes.
4. Unused dp position.
5. See Internal Circuit Diagram.
6. Redundant cathode.
7. See part number table for L.H.D.P. and R.H.D.P. designation.

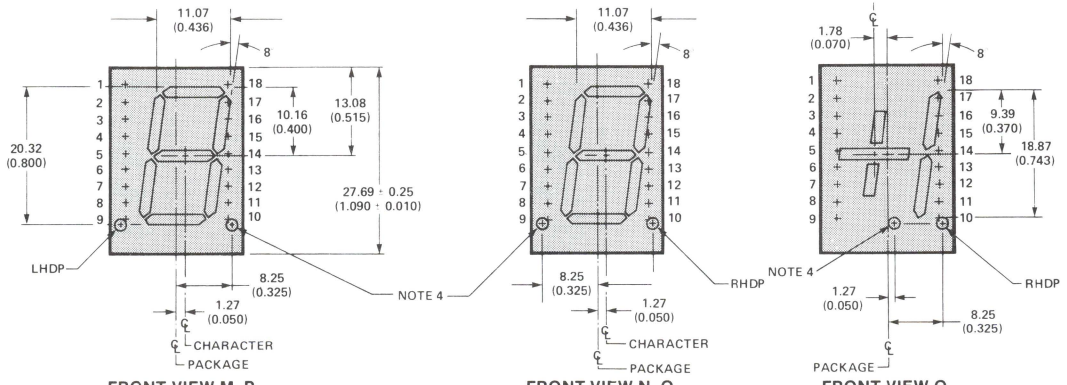
Package Dimensions (HDSP-H101 Series)

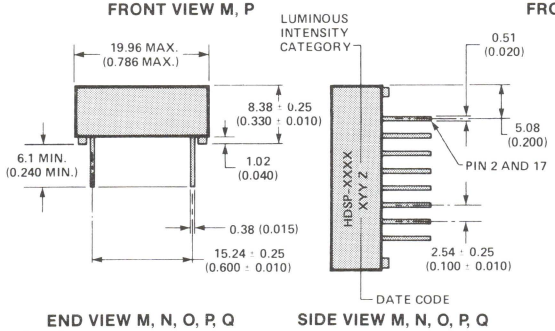


PIN	FUNCTION			
	I	J	K	L
1	CATHODE e	ANODE e	CATHODE c	ANODE c
2	CATHODE d	ANODE d	ANODE c, d	CATHODE c, d
3	ANODE[4]	CATHODE[5]	CATHODE b	ANODE b
4	CATHODE c	ANODE c	ANODE a, b, DP	CATHODE a, b, DP
5	CATHODE DP	ANODE DP	CATHODE DP	ANODE DP
6	CATHODE b	ANODE b	CATHODE a	ANODE a
7	CATHODE a	ANODE a	ANODE a, b, DP	CATHODE a, b, DP
8	ANODE[4]	CATHODE[5]	ANODE c, d	CATHODE c, d
9	CATHODE f	ANODE f	CATHODE d	ANODE d
10	CATHODE g	ANODE g	NO PIN	NO PIN

Notes:
1. All dimensions in millimetres (inches).
2. Maximum.
3. All untoleranced dimensions are for reference only.
4. Redundant anodes.
5. Redundant cathodes.

Package Dimensions (HDSP-N100 Series)

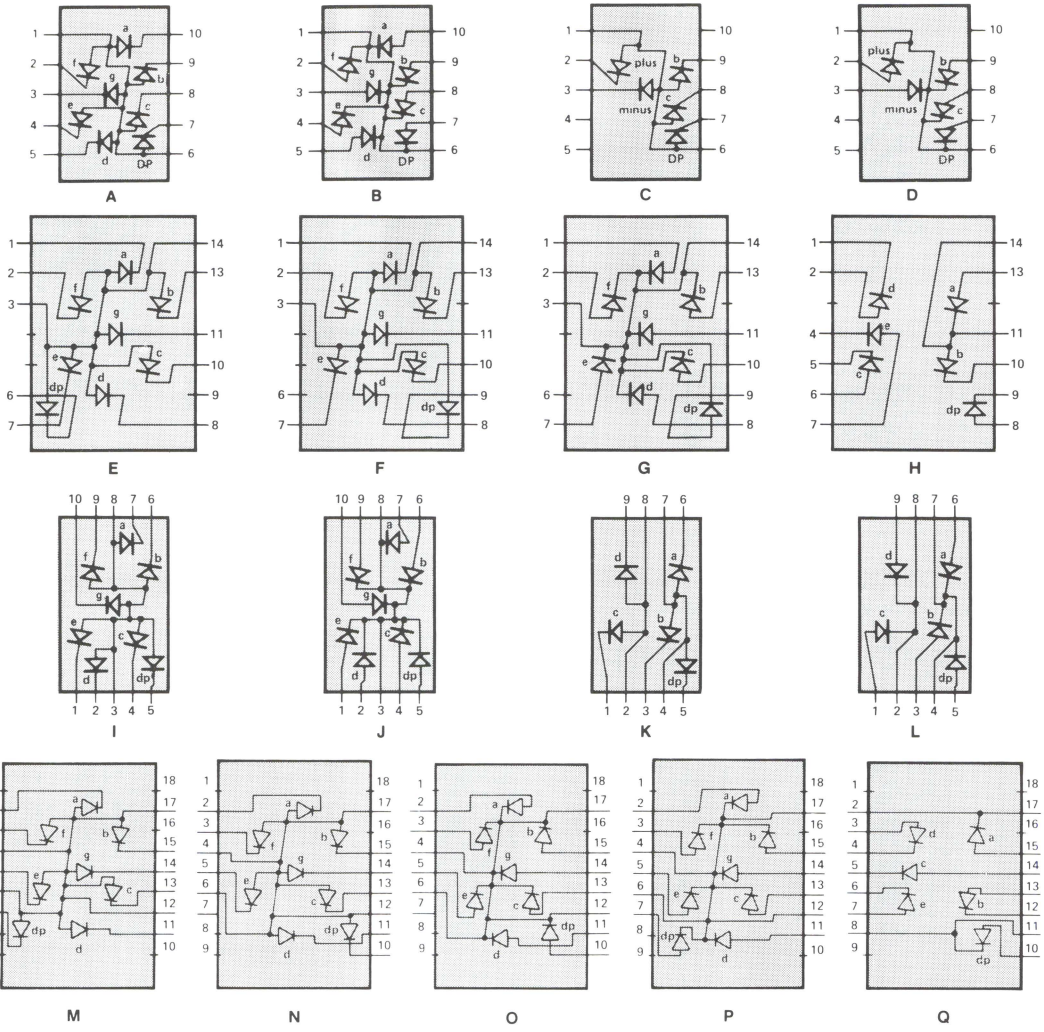




Pin	Function				
	M	N	O	P	Q
1	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
2	CATHODE a	CATHODE a	ANODE a	ANODE a	CATHODE a
3	CATHODE f	CATHODE f	ANODE f	ANODE f	ANODE d
4	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE d
5	CATHODE e	CATHODE e	ANODE e	ANODE e	CATHODE c
6	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE e
7	CATHODE dp	NO CONNEC	NO CONNEC	ANODE dp	ANODE e
8	NO PIN	NO PIN	NO PIN	NO PIN	CATHODE dp
9	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
10	NO PIN	CATHODE dp	ANODE dp	NO PIN	ANODE dp
11	CATHODE d	CATHODE d	ANODE d	ANODE d	CATHODE dp
12	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE b
13	CATHODE c	CATHODE c	ANODE c	ANODE c	ANODE b
14	CATHODE g	CATHODE g	ANODE g	ANODE g	ANODE c
15	CATHODE b	CATHODE b	ANODE b	ANODE b	ANODE a
16	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
17	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE a
18	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN

NOTES:
1. Dimensions in millimeters and (inches).
2. All untoleranced dimensions are for reference only.
3. Redundant anodes.
4. Unused dp position.
5. See Internal Circuit Diagram.
6. Redundant Cathodes.
7. See part number table for LHDP and RHDP designation.

Internal Circuit Diagram



Absolute Maximum Ratings (All Products)

Average Power per Segment or DP (T_A = 25° C) ..... 37 mW

Peak Forward Current per Segment or DP (T_A = 25° C)[1] ..... 45 mA

Average or DC Forward Current per Segment[2] or DP (T_A = 25° C) ..... 15 mA

Operating Temperature Range ..... -20° C to 85° C

Storage Temperature Range ..... -55° C to +100° C

Reverse Voltage per Segment or DP ..... 3.0 V

Lead Solder Temperature (1.59 mm [1/16 inch] below seating plane) ..... 260° C for 3 sec.

Notes:

1. Do not exceed maximum average current per segment.
2. For the HDSP-A101, HDSP-E100 and HDSP-H101 series, derate maximum average current above T_A = 75° C at 0.5 mA/° C per segment, see Figure 1. For the HDSP-N100 series, the maximum average current does not need to be derated at 85° C operation.

Electrical/Optical Characteristics at $T_A = 25°C$

Description	Symbol	Device HDSP-	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[1,2] (Digit Average)	I_V	A101 Series	1 mA DC	315	600		µcd
			5 mA DC		3600		
			20 mA Pk: 1 of 4 Duty Factor		3300		
		E100 Series	1 mA DC	390	650		µcd
			5 mA DC		3900		
			20 mA Pk: 1 of 4 Duty Factor		3600		
		H101 Series	1 mA DC	400	700		µcd
			5 mA DC		4200		
			20 mA Pk: 1 of 4 Duty Factor		3900		
		N100 Series	1 mA DC	270	590		µcd
			5 mA DC		3500		
			20 mA Pk: 1 of 4 Duty Factor		3300		
Peak Wavelength	λ_{PEAK}	All Devices			650		nm
Dominant Wavelength[3]	λ_d	All Devices			642		nm
Forward Voltage/Segment or DP	V_F	All Devices	I_F = 1 mA		1.6		V
			I_F = 5 mA		1.7		
			I_F = 20 mA Pk		1.8	2.2	
Reverse Voltage/Segment or DP	V_R	All Devices	I_R = 100 µA	3.0	15		V
Temperature Coefficient of V_F/Segment or DP	ΔV_F/° C				-2 mV		mV/° C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J\text{-}PIN}$	A101			255		° C/W/Seg
		E100			340		
		H101			400		
		N100			430		

Notes:
1. Case temperature of the device immediately prior to the intensity measurement is 25° C.
2. The digits are categorized for luminous intensity with the intensity category designated by a letter on the side of the package.
3. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and is that single wavelength which defines the color of the device.

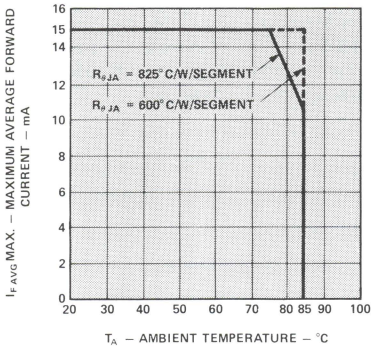


Figure 1. Maximum Allowable Average or DC Current per Segment vs. Ambient Temperature

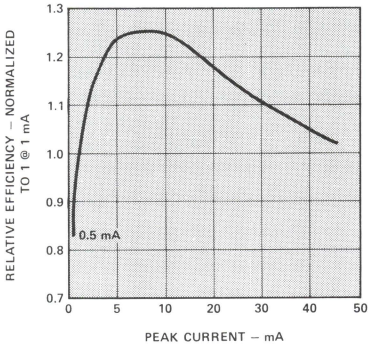


Figure 2. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

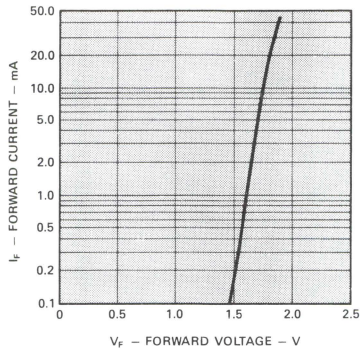


Figure 3. Forward Current vs. Forward Voltage

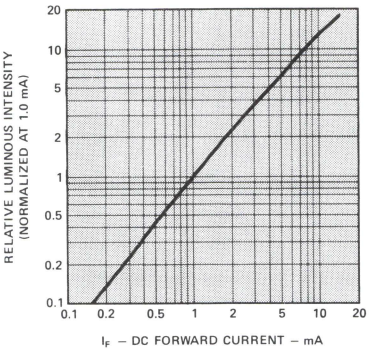


Figure 4. Relative Luminous Intensity vs. DC Forward Current

Electrical

The HDSP-A101/E100/H101/N100 series of display devices are composed of light emitting diodes, with the light from each LED optically stretched to form individual segments and decimal points. These displays have their p-n junctions formed in AlGaAs epitaxial layers grown on a GaAs substrate.

These display devices are well suited for strobed operation. The typical forward voltage values, scaled from Figure 3, should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F MAX model:

V_F MAX = 2.0 V + I_{PEAK} (10 Ω)
For: $I_{PEAK} \geq 20$ mA
V_F MAX = 1.8 V + I_{DC} (20Ω)
For: $I_{DC} \leq 20$ mA

These displays are compatible with monolithic LED display drivers. See Application Note 1006 for more information.

Contrast Enhancement

The objective of contrast enhancement is to provide good display readability in the end use ambient light. The concept is to employ both luminance and chrominance contrast techniques to enhance readability by having the OFF-segments blend into the display background and the ON-segments stand out vividly against this same background. Therefore, these display devices are assembled with a gray package and matching encapsulating epoxy in the segments.

Contrast enhancement may be achieved by using one of the following suggested filters:

Panelgraphic RUBY RED 60
SGL Homalite H100-1605 RED
3M Louvered Filter R6610 RED or N0210
GRAY

Mechanical

To optimize device optical performance, specially developed plastics are used which restrict the solvents that may be used for cleaning. It is recommended that only mixtures of Freon (F113) and alcohol be used for vapor cleaning processes, with an immersion time in the vapors of less than two (2) minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolve DI-15 or DE-15, Arklone A or K. A 60°C (140°F) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and a thorough air dry. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, Ethanol, Isopropanol or water with a mild detergent.

Such cleaning agents from the ketone family (acetone, methyl ethyl ketone, etc.) and from the chlorinated hydrocarbon family (methylene chloride, trichloroethylene, carbon tetrachloride, etc.) are not recommended for cleaning LED parts. All of these various solvents attack or dissolve the encapsulating epoxies used to form the packages of plastic LED devices.

HEWLETT PACKARD

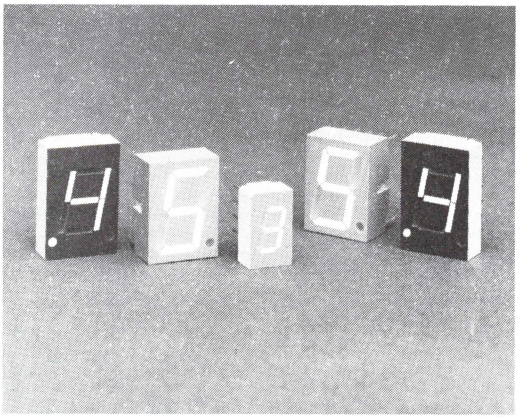
LOW CURRENT SEVEN SEGMENT DISPLAYS

HIGH EFFICIENCY RED

7.6 mm (0.3 in) HDSP-7511 SERIES
10.9 mm (0.43 in) HDSP-3350 SERIES
14.2 mm (0.56 in) HDSP-5551 SERIES

Features

- **LOW POWER CONSUMPTION**
  Typical Power Consumption is 3 mW/Seg at 2 mA Drive
- **TYPICAL INTENSITY OF 300 μcd/Seg AT 2 mA DRIVE**
- **CAPABLE OF HIGH CURRENT DRIVE**
  Excellent for Long Digit String Multiplexing
- **COMPATIBLE WITH MONOLITHIC LED DISPLAY DRIVERS**
- **THREE CHARACTER SIZES**
  7.6 mm (0.3 in), 10.9 mm (0.43 in), 14.2 mm (0.56 in)
- **COMMON ANODE OR COMMON CATHODE**
  Overflow ±1 Character
- **EXCELLENT CHARACTER APPEARANCE**
  Wide Viewing Angle
- **CATEGORIZED FOR LUMINOUS INTENSITY**
  Use of Like Categories Yields a Uniform Display



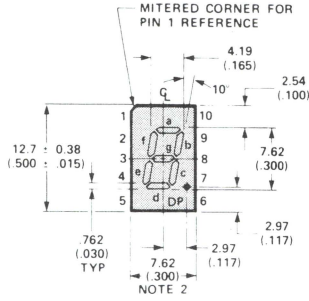
Description

The HDSP-7511, HDSP-3350, HDSP-5551 series are 7.6 mm (0.3 in), 10.9 mm (0.43 in) and 14.2 mm (0.56 in) high efficiency red displays featuring low power consumption. The HDSP-7511 series are designed for viewing distances up to 2 meters, the HDSP-3350 series for viewing distances up to 5 meters, and the HDSP-5551 series for viewing distances up to 7 meters. Typical applications include instruments, scales, point-of-sale terminals and meters.

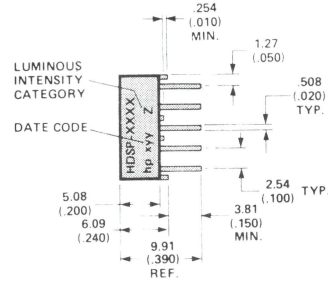
Devices

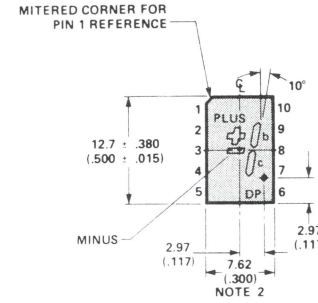
Part Number	Color	Description	Package Drawing
HDSP-7511	High Efficiency Red	7.6 mm Common Anode Right Hand Decimal	A
HDSP-7513		7.6 mm Common Cathode Right Hand Decimal	B
HDSP-7517		7.6 mm Overflow ±1 Common Anode	C
HDSP-7518		7.6 mm Overflow ±1 Common Cathode	D
HDSP-3350	High Efficiency Red	10.9 mm Common Anode Left Hand Decimal	E
HDSP-3351		10.9 mm Common Anode Right Hand Decimal	F
HDSP-3353		10.9 mm Common Cathode Right Hand Decimal	G
HDSP-3356		10.9 mm Universal Overflow ±1 Right Hand Decimal	H
HDSP-5551	High Efficiency Red	14.2 mm Common Anode Right Hand Decimal	I
HDSP-5553		14.2 mm Common Cathode Right Hand Decimal	J
HDSP-5557		14.2 mm Overflow ±1 Common Anode	K
HDSP-5558		14.2 mm Overflow ±1 Common Cathode	L

Package Dimensions (HDSP-7511 Series)

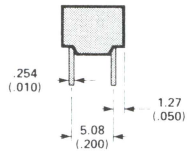


A, B





C, D

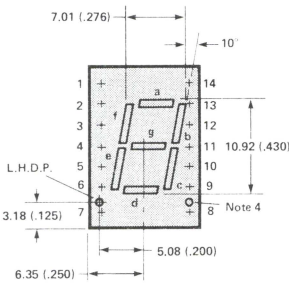


Notes:

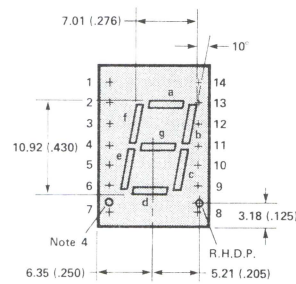
1. All dimensions in millimetres (inches).
2. Maximum.
3. All untoleranced dimensions are for reference only.
4. Redundant anodes.
5. Redundant cathodes.

	FUNCTION			
PIN	A	B	C	D
1	ANODE [4]	CATHODE [5]	ANODE [4]	CATHODE [5]
2	CATHODE f	ANODE f	CATHODE PLUS	ANODE PLUS
3	CATHODE g	ANODE g	CATHODE MINUS	ANODE MINUS
4	CATHODE e	ANODE e	NC	NC
5	CATHODE d	ANODE d	NC	NC
6	ANODE [4]	CATHODE [5]	ANODE [4]	CATHODE [5]
7	CATHODE DP	ANODE DP	CATHODE DP	ANODE DP
8	CATHODE c	ANODE c	CATHODE c	ANODE c
9	CATHODE b	ANODE b	CATHODE b	ANODE b
10	CATHODE a	ANODE a	NC	NC

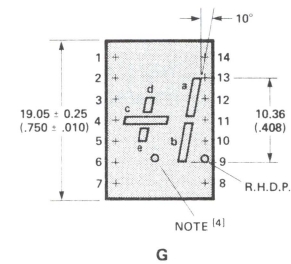
Package Dimensions (HDSP-3350 Series)



E

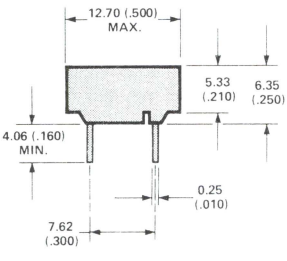


F,H

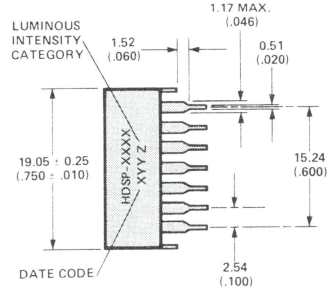


G

FRONT VIEW



END VIEW



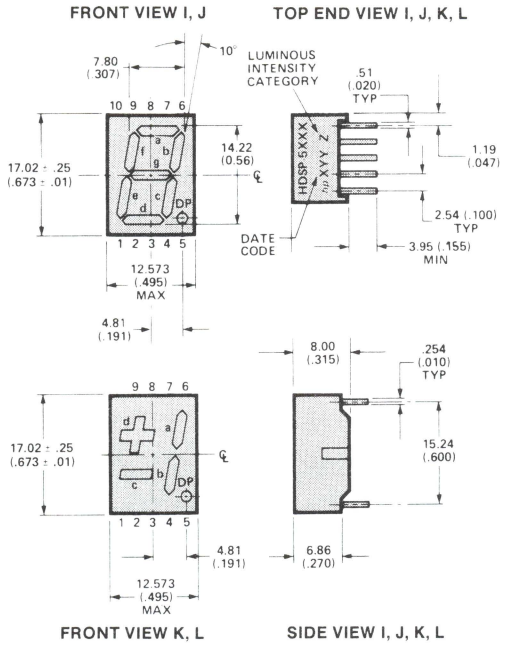
SIDE VIEW

	FUNCTION			
PIN	E	F	G	H
1	CATHODE a	CATHODE a	ANODE a	CATHODE d
2	CATHODE f	CATHODE f	ANODE f	ANODE d
3	ANODE [3]	ANODE [3]	CATHODE [6]	NO PIN
4	NO PIN	NO PIN	NO PIN	CATHODE c
5	NO PIN	NO PIN	NO PIN	CATHODE e
6	CATHODE dp	NO CONN. [5]	NO CONN. [5]	ANODE e
7	CATHODE e	CATHODE e	ANODE e	ANODE c
8	CATHODE d	CATHODE d	ANODE d	ANODE dp
9	NO CONN. [5]	CATHODE dp	ANODE dp	CATHODE dp
10	CATHODE c	CATHODE c	ANODE c	CATHODE b
11	CATHODE g	CATHODE g	ANODE g	CATHODE a
12	NO PIN	NO PIN	NO PIN	NO PIN
13	CATHODE b	CATHODE b	ANODE b	ANODE a
14	ANODE [3]	ANODE [3]	CATHODE [6]	ANODE b

NOTES:

1. Dimensions in millimeters and (inches).
2. All untoleranced dimensions are for reference only
3. Redundant anodes.
4. Unused dp position.
5. See Internal Circuit Diagram.
6. Redundant cathode.
7. See part number table for L.H.D.P. and R.H.D.P. designation.

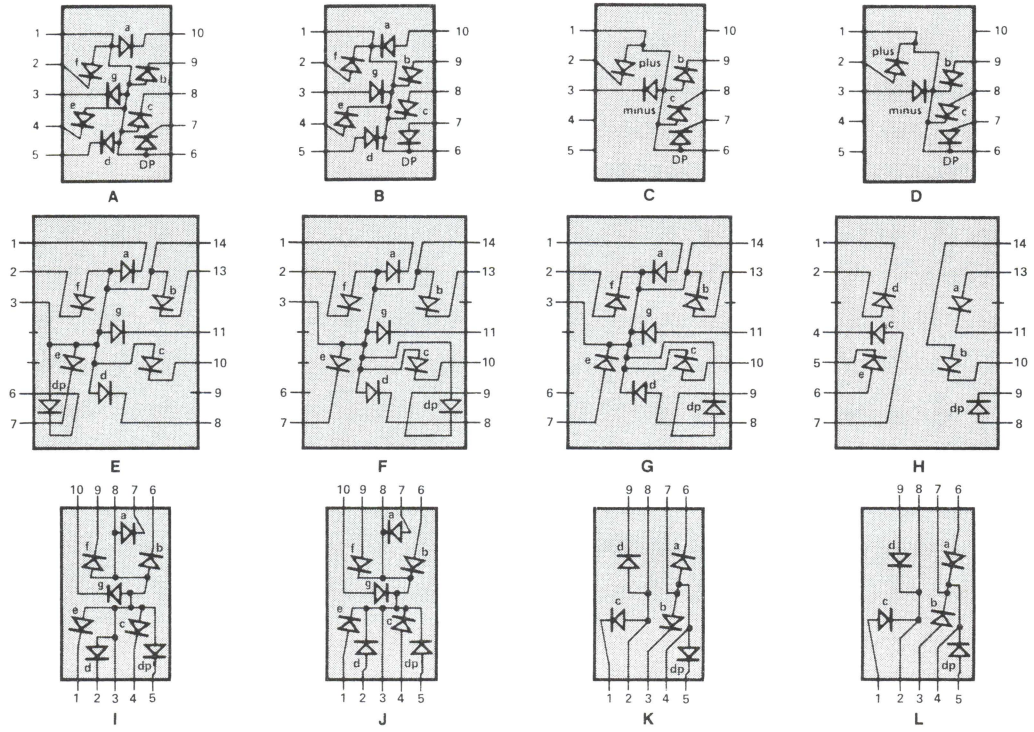
Package Dimensions (HDSP-5551 Series)



PIN	FUNCTION			
	I	J	K	L
1	CATHODE e	ANODE e	CATHODE c	ANODE c
2	CATHODE d	ANODE d	ANODE c, d	CATHODE c, d
3	ANODE[4]	CATHODE[5]	CATHODE b	ANODE b
4	CATHODE c	ANODE c	ANODE a, b, DP	CATHODE a, b, DP
5	CATHODE DP	ANODE DP	CATHODE DP	ANODE DP
6	CATHODE b	ANODE b	CATHODE a	ANODE a
7	CATHODE a	ANODE a	ANODE a, b, DP	CATHODE a, b, DP
8	ANODE[4]	CATHODE[5]	ANODE c, d	CATHODE c, d
9	CATHODE f	ANODE f	CATHODE d	ANODE d
10	CATHODE g	ANODE g	NO PIN	NO PIN

Notes:
1. All dimensions in millimetres (inches).
2. Maximum.
3. All untoleranced dimensions are for reference only.
4. Redundant anodes.
5. Redundant cathodes.

Internal Circuit Diagram



Absolute Maximum Ratings (All Products)

Average Power per Segment
or DP (T_A = 25° C) ..... 52 mW

Peak Forward Current per Segment
or DP (T_A = 25° C)[1] ..... 45 mA

Average or DC Forward Current per Segment[2]
or DP (T_A == 25° C) ..... 15 mA

Operating Temperature Range ..... −40° C to +85° C

Storage Temperature Range ..... −55° C to +100° C

Reverse Voltage per Segment or DP ..... 3.0 V

Lead Solder Temperature
(1.59 mm [1/16 inch] below
seating plane) ..... 260° C for 3 sec.

Notes:
1. Do not exceed maximum average current per segment.
2. Derate maximum average current above T_A = 65° C at 0.4 mA/° C per segment, see Figure 1. Derate maximum DC current above T_A = 78° C at 0.6 mA/° C per segment.

Electrical/Optical Characteristics at T_A = 25° C

HIGH EFFICIENCY RED HDSP-7511 SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[3] (Digit Average)	I_V	2 mA DC	160	270		µcd
		5 mA DC		1050		
		40 mA Pk: 1 of 4 Duty Factor		3500		
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength[4]	λ_d			626		nm
Forward Voltage/Segment or DP	V_F	I_F = 2 mA		1.6		V
		I_F = 5 mA		1.7		
		I_F = 20 mA Pk		2.1	2.5	
Reverse Voltage/Segment or DP[5]	V_R	I_R = 100 µA	3.0	30.0		V
Temperature Coefficient of V_F/Segment or DP	ΔV_F/° C			−2.0		mV/° C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J\text{-}PIN}$			200		° C/W/ Seg

HIGH EFFICIENCY RED HDSP-3350 SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[3] (Digit Average)	I_V	2 mA DC	200	300		µcd
		5 mA DC		1200		
		40 mA Pk: 1 of 4 Duty Factor		3900		
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength[4]	λ_d			626		nm
Forward Voltage/Segment or DP	V_F	I_F = 2 mA		1.6		V
		I_F = 5 mA		1.7		
		I_F = 20 mA Pk		2.1	2.5	
Reverse Voltage/Segment or DP[5]	V_R	I_R = 100 µA	3.0	30.0		V
Temperature Coefficient of V_F/Segment or DP	ΔV_F/° C			−2.0		mV/° C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J\text{-}PIN}$			282		° C/W/ Seg

HIGH EFFICIENCY RED HDSP-5551 SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[3] (Digit Average)	I_V	2 mA DC	270	370		μcd
		10 mA DC		3400		
		40 mA Pk: 1 of 4 Duty Factor		4800		
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength[4]	λ_d			626		nm
Forward Voltage/Segment or DP	V_F	I_F = 2 mA		1.6		V
		I_F = 5 mA		1.7		
		I_F = 20 mA Pk		2.1	2.5	
Reverse Voltage/Segment or DP[5]	V_R	I_R = 100 μA	3.0	30.0		V
Temperature Coefficient of V_F/Segment or DP	ΔV_F/°C			-2.0		mV/°C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J\text{-}PIN}$			345		°C/W/ Seg

3. The digits are categorized for luminous intensity with the intensity category designated by a letter on the right hand side of the package. The luminous intensity minimum and categories are determined by computing the numerical average of the individual segment intensities, decimal point not included. Operation at less than 2 mA DC or peak current per segment may cause objectionable display segment matching and is not recommended.
4. The dominant wavelength is derived from the C.I.E. Chromaticity diagram and is that single wavelength which defines the color of the device.
5. Typical specification for reference only. Do not exceed absolute maximum ratings.

HDSP-7511/-3350/-5551 SERIES

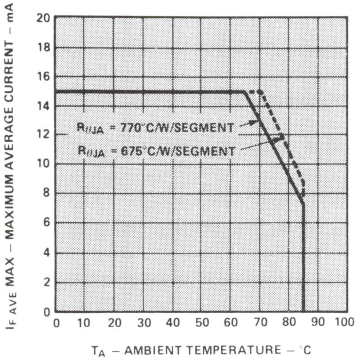


Figure 1. Maximum Allowable Average Current per Segment as a Function of Ambient Temperature

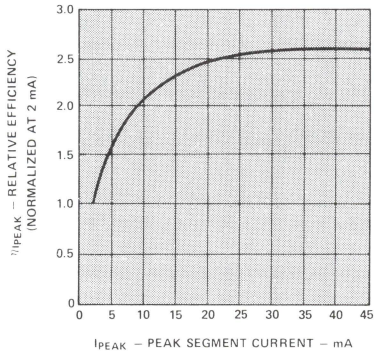


Figure 2. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current per Segment

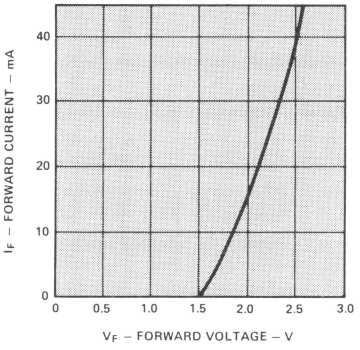


Figure 3. Forward Current vs. Forward Voltage

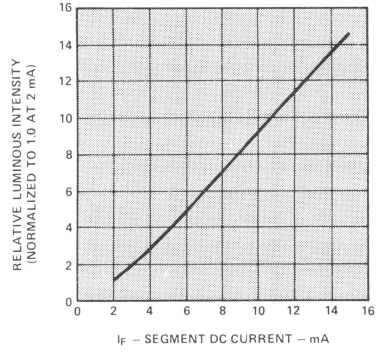


Figure 4. Relative Luminous Intensity vs. DC Forward Current

Electrical

The HDSP-7511/-3350/-5551 series of display devices are composed of light emitting diodes, with the light from each LED optically stretched to form individual segments and decimal points. These displays have their p-n junctions diffused into GaAsP epitaxial layer on a GaP substrate.

These display devices are well suited for strobed operation. The typical forward voltage values, scaled from Figure 3, should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F MAX model:

V_F MAX = 1.75 V + I_{PEAK} (38Ω)
For: $I_{PEAK} \geq 20$ mA
V_F MAX = 1.6 V + I_{DC} (45Ω)
For: 2 mA ≤ I_{DC} ≤ 20 mA

These displays are compatible with monolithic LED display drivers. See Application Note 1006 for more information.

Contrast Enhancement

The objective of contrast enhancement is to provide good display readability in the end use ambient light. The concept is to employ both luminance and chrominance contrast techniques to enhance readability by having the OFF-segments blend into the display background and the ON-segments stand out vividly against this same background. Therefore, these display devices are assembled with a gray package and matching encapsulating epoxy in the segments.

Contrast enhancement may be achieved by using one of the following suggested filters:

Panelgraphic SCARLET RED 65 or GRAY 10
SGL Homalite H100-1670 RED or -1266
GRAY
3M Louvered Filter R6310 RED or N0210
GRAY

Mechanical

To optimize device optical performance, specially developed plastics are used which restrict the solvents that may be used for cleaning. It is recommended that only mixtures of Freon (F113) and alcohol be used for vapor cleaning processes, with an immersion time in the vapors of less than two (2) minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolve DI-15 or DE-15, Arklone A or K. A 60°C (140°F) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and a thorough air dry. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, Ethanol, Isopropanol or water with a mild detergent.

Such cleaning agents from the ketone family (acetone, methyl ethyl ketone, etc.) and from the chlorinated hydrocarbon family (methylene chloride, trichloroethylene, carbon tetrachloride, etc.) are not recommended for cleaning LED parts. All of these various solvents attack or dissolve the encapsulating epoxies used to form the packages of plastic LED devices.

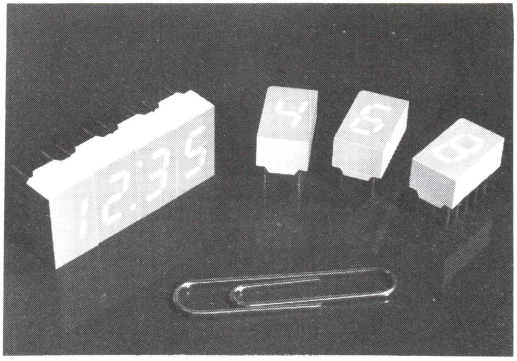
HEWLETT PACKARD

7.6 mm (.3 inch) MICRO BRIGHT 7 SEGMENT DISPLAYS

RED	HDSP-7301
HIGH EFFICIENCY RED	HDSP-7501
YELLOW	HDSP-7401
HIGH PERFORMANCE GREEN	HDSP-7801

Features

- **HIGH BRIGHTNESS**
  Package Optimized for High Ambient Conditions
- **COMPACT PACKAGE**
  0.300 x 0.500 inches
- **CHOICE OF FOUR COLORS:**
  Red, High Efficiency Red, Yellow,
  High Performance Green
- **EXCELLENT CHARACTER APPEARANCE:**
  Evenly Lighted Segments
  Mitered Segments
  Wide Viewing Angle
  Grey Package Provides Optimum On-Off Contrast
- **EASY MOUNTING ON PC BOARDS OR SOCKETS**
  5.08 mm (0.2 inch) DIP Leads on 2.54 mm
  (0.1 inch) Centers
- **AVAILABLE WITH COLON FOR CLOCK DISPLAY**
- **COMMON ANODE OR COMMON CATHODE**
  Right Hand Decimal Point
  Overflow ±1 Character
- **CATEGORIZED FOR LUMINOUS INTENSITY; YELLOW AND GREEN ALSO CATEGORIZED FOR COLOR**
  Use of Like Category Yields a Uniform Display



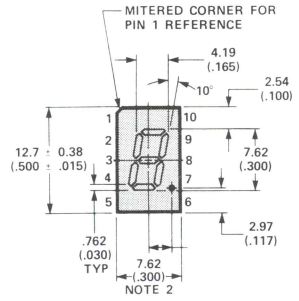
Description

The HDSP-7301/-7501/-7401/7801 Series are 7.6 mm (0.3 inch) character LED seven segment displays in a compact package. Designed for viewing distances up to 3 metres (10 feet), these displays are ideal for high ambient applications where space is at a premium. Typical applications include instruments, aircraft and marine equipment, point-of-sale terminals, clocks, and appliances.

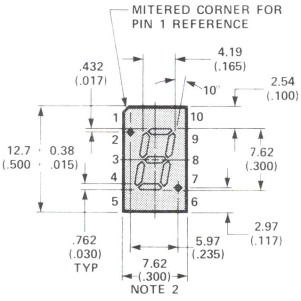
Devices

Part Number	Color	Description	Package Drawing
HDSP-7301	Red	Common Anode Right Hand Decimal	A
HDSP-7311	Bright Red	Common Anode Right Hand Decimal	A
HDSP-7302	Red	Common Anode Right Hand Decimal, Colon	B
HDSP-7303	Red	Common Cathode Right Hand Decimal	C
HDSP-7313	Bright Red	Common Cathode Right Hand Decimal	C
HDSP-7304	Red	Common Cathode Right Hand Decimal, Colon	D
HDSP-7307	Red	Overflow ±1 Common Anode	E
HDSP-7317	Bright Red	Overflow ±1 Common Anode	E
HDSP-7308	Red	Overflow ±1 Common Cathode	F
HDSP-7318	Bright Red	Overflow ±1 Common Cathode	F
HDSP-7501	HER	Common Anode Right Hand Decimal	A
HDSP-7502		Common Anode Right Hand Decimal, Colon	B
HDSP-7503		Common Cathode Right Hand Decimal	C
HDSP-7504		Common Cathode Right Hand Decimal, Colon	D
HDSP-7507		Overflow ±1 Common Anode	E
HDSP-7508		Overflow ±1 Common Cathode	F
HDSP-7401	Yellow	Common Anode Right Hand Decimal	A
HDSP-7402		Common Anode Right Hand Decimal, Colon	B
HDSP-7403		Common Cathode Right Hand Decimal	C
HDSP-7404		Common Cathode Right Hand Decimal, Colon	D
HDSP-7407		Overflow ±1 Common Anode	E
HDSP-7408		Overflow ±1 Common Cathode	F
HDSP-7801	Green	Common Anode Right Hand Decimal	A
HDSP-7802		Common Anode Right Hand Decimal, Colon	B
HDSP-7803		Common Cathode Right Hand Decimal	C
HDSP-7804		Common Cathode Right Hand Decimal, Colon	D
HDSP-7807		Overflow ±1 Common Anode	E
HDSP-7808		Overflow ±1 Common Cathode	F

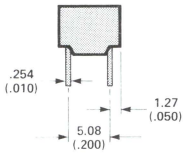
Package Dimensions

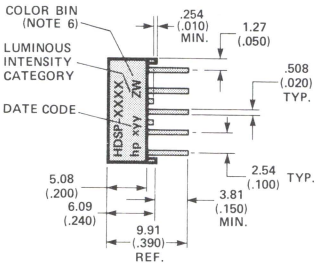


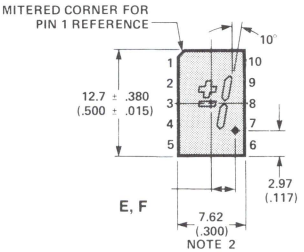
A, C



B, D





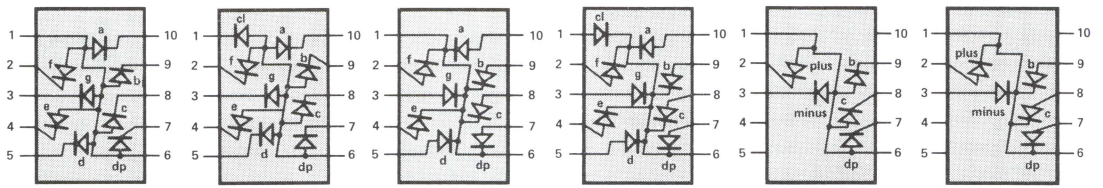


E, F

Notes:
1. All dimensions in millimetres (inches).
2. Maximum.
3. All untoleranced dimensions are for reference only.
4. Redundant anodes.
5. Redundant cathodes.
6. For HDSP-7401/-7801 series product only.

	FUNCTION					
PIN	A	B	C	D	E	F
1	ANODE[4]	CATHODE COLON	CATHODE[5]	ANODE COLON	ANODE[4]	CATHODE[5]
2	CATHODE f	CATHODE f	ANODE f	ANODE f	CATHODE PLUS	ANODE PLUS
3	CATHODE g	CATHODE g	ANODE g	ANODE g	CATHODE MINUS	ANODE MINUS
4	CATHODE e	CATHODE e	ANODE e	ANODE e	NC	NC
5	CATHODE d	CATHODE d	ANODE d	ANODE d	NC	NC
6	ANODE[4]	ANODE	CATHODE[5]	CATHODE	ANODE[4]	CATHODE[5]
7	CATHODE DP	CATHODE DP	ANODE DP	ANODE DP	CATHODE DP	ANODE DP
8	CATHODE c	CATHODE c	ANODE c	ANODE c	CATHODE c	ANODE c
9	CATHODE b	CATHODE b	ANODE b	ANODE b	CATHODE b	ANODE b
10	CATHODE a	CATHODE a	ANODE a	ANODE a	NC	NC

Internal Circuit Diagram



Absolute Maximum Ratings

	HDSP-7301/ -7311 Series	HDSP-7501 Series	HDSP-7401 Series	HDSP-7801 Series
Average Power Dissipation per Segment or D.P.	73 mW	105 mW	81 mW	105 mW
Operating Temperature Range	-40° C to +100° C			
Storage Temperature Range	-55° C to +100° C			
Peak Forward Current per Segment or D.P.[7]	150 mA	90 mA	60 mA	90 mA
DC Forward Current per Segment or D.P.[8]	25 mA	30 mA	20 mA	30 mA
Reverse Voltage per Segment or D.P.	3 V	3 V	3 V	3 V
Lead Soldering Temperature 1.59 mm (1/16 inch) below seating plane	260° C for 3 sec.			

7. See Figures 1, 6, 7, and 8 to establish pulsed operating conditions. (Figure 1, HDSP-7301 Series; Figure 6, HDSP-7501 Series; Figure 7, HDSP-7401 Series; Figure 8, HDSP-7801 Series).
8. See Figures 2, 9, 10, and 11 to derate maximum DC current. (Figure 2, HDSP-7301 Series; Figure 9, HDSP-7501 Series; Figure 10, HDSP-7401 Series; Figure 11, HDSP-7801 Series).

Electrical/Optical Characteristics at $T_A = 25°C$

STANDARD RED HDSP-7301 SERIES

Description	Device HDSP-	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[9] (Digit Average)	7301	I_V	10 mA DC		500		μcd
			20 mA DC	600	1100		
	7311		10 mA DC		610		
			20 mA DC	770	1355		
Peak Wavelength		λ_{PEAK}			655		nm
Dominant Wavelength[10]		λ_d			640		nm
Forward Voltage, any Segment or D.P.		V_F	$I_F = 20$ mA		1.6	2.0	V
Reverse Voltage, any Segment or D.P.[12]		V_R	$I_R = 100$ μA	3.0	12.0		V
Temperature Coefficient of Forward Voltage		$\Delta V_F/°C$			-2.0		mV/°C
Thermal Resistance LED Junction-to-Pin		$R\theta_{J-PIN}$			200		°C/W/ Seg

HIGH EFFICIENCY RED HDSP-7501 SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[9] (Digit Average)	I_V	5 mA D.C.	360	980		μcd
		20 mA D.C.		5390		
		60 mA Pk: 1 of 6 Duty Factor		3430		
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength[10]	λ_d			626		nm
Forward Voltage/Segment or D.P.	V_F	$I_F = 5$ mA		1.7		V
		$I_F = 20$ mA		2.0	2.5	
		$I_F = 60$ mA		2.8		
Reverse Voltage/Segment or D.P.[12]	V_R	$I_R = 100$ μA	3.0	30.0		V
Temperature Coefficient of V_F/Segment or D.P.	$\Delta V_F/°C$			—2.0		mV/°C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			200		°C/W/ Seg

YELLOW HDSP-7401 SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[9] (Digit Average)	I_V	5 mA D.C.	225	480		μcd
		20 mA D.C.		2740		
		60 mA Pk: 1 of 6 Duty Factor		1700		
Peak Wavelength	λ_{PEAK}			583		nm
Dominant Wavelength[10,11]	λ_d		581.5	586	592.5	nm
Forward Voltage/Segment or D.P.	V_F	$I_F = 5$ mA		1.8		V
		$I_F = 20$ mA		2.2	2.5	
		$I_F = 60$ mA		3.1		
Reverse Voltage/Segment or D.P.[12]	V_R	$I_R = 100$ μA	3.0	50.0		V
Temperature Coefficient of V_F/Segment or D.P.	$\Delta V_F/°C$			—2.0		mV/°C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			200		°C/W/ Seg

9. The digits are categorized for luminous intensity with the intensity category designated by a letter on the right hand side of the package. The luminous intensity minimum and categories are determined by computing the numerical average of the individual segment intensities, decimal point not included.
10. The dominant wavelength is derived from the C.I.E. Chromaticity diagram and is that single wavelength which defines the color of the device.
11. The HDSP-7401/-7801 series are categorized as to dominant wavelength with the category designated by a number adjacent to the intensity category letter.
12. Typical specification for reference only. Do not exceed absolute maximum ratings.

HIGH PERFORMANCE GREEN HDSP-7801 SERIES

Description	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[9] (Digit Average)	I_V	5 mA D.C.		545		μcd
		10 mA D.C.	570	1480		
		60 mA Pk: 1 of 6 Duty Factor		1935		
Peak Wavelength	λ_{PEAK}			566		nm
Dominant Wavelength[10, 11] (Digit Average)	λ_d			571	577	nm
Forward Voltage/Segment or D.P.	V_F	I_F = 10 mA		2.1	2.5	V
Reverse Voltage/Segment or D.P.[12]	V_R	I_R = 100 μA	3.0	50.0		V
Thermal Resistance LED Junction-to-Pin	$R\theta_{J\text{-}PIN}$			200		°C/W/ Seg

HDSP-7301 SERIES

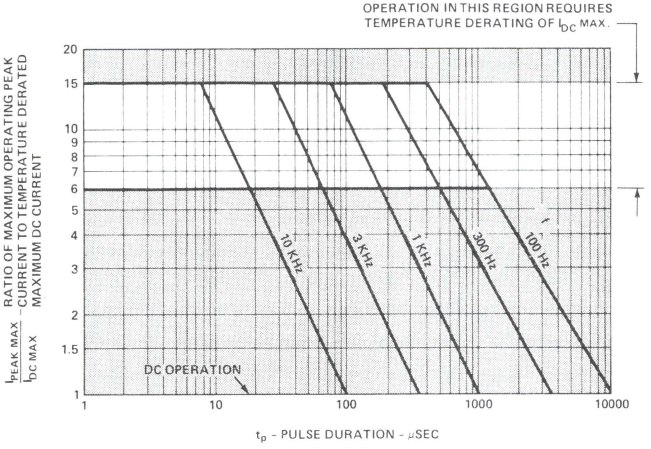


Figure 1. Maximum Tolerable Peak Current vs. Pulse Duration

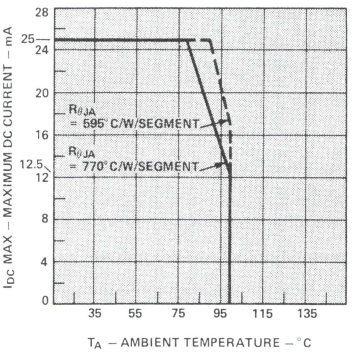


Figure 2. Maximum Allowable DC Current Dissipation per Segment as a Function of Ambient Temperature

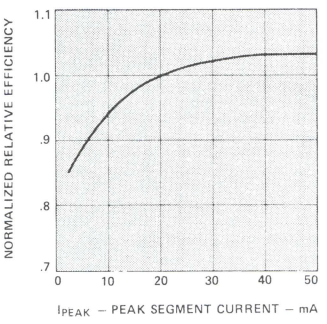


Figure 3. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Current per Segment

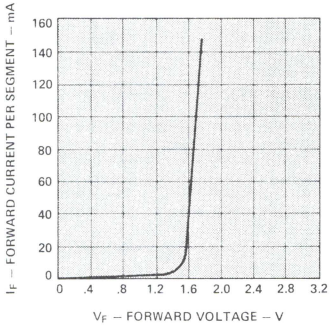


Figure 4. Forward Current vs. Forward Voltage

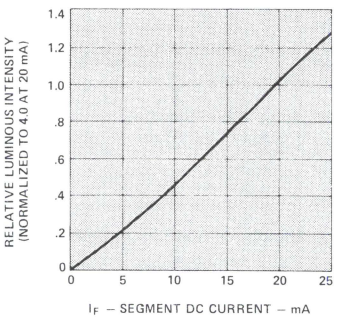


Figure 5. Relative Luminous Intensity vs. DC Forward Current

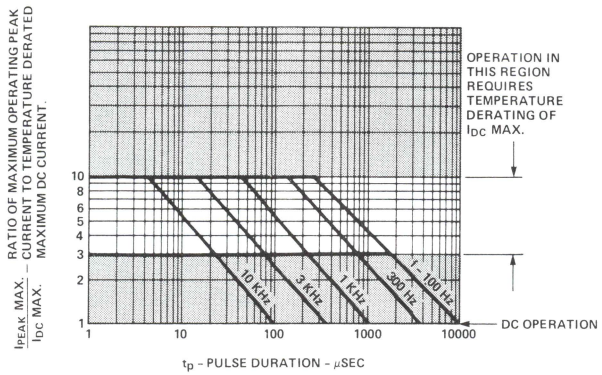


Figure 6. Maximum Tolerable Peak Current vs. Pulse Duration — HDSP-7501 Series

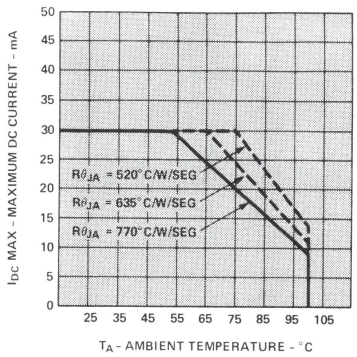


Figure 9. Maximum Allowable DC Current and DC Power Dissipation per Segment as a Function of Ambient Temperature — HDSP-7501 Series

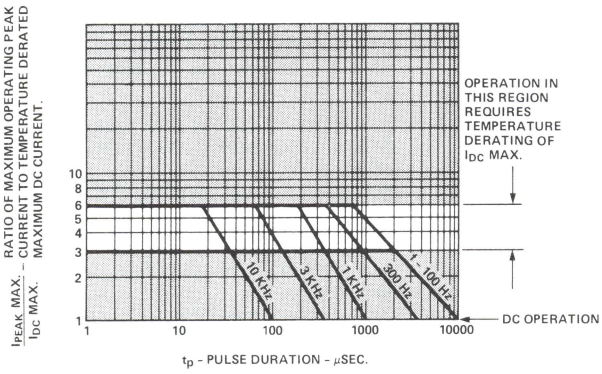


Figure 7. Maximum Tolerable Peak Current vs. Pulse Duration — HDSP-7401 Series

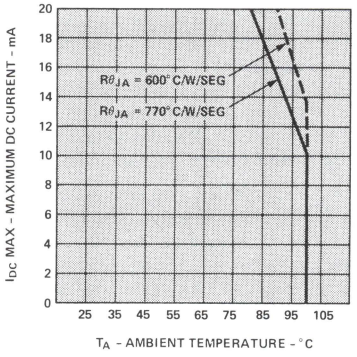


Figure 10. Maximum Allowable DC Current and DC Power Dissipation per Segment as a Function of Ambient Temperature — HDSP-7401 Series

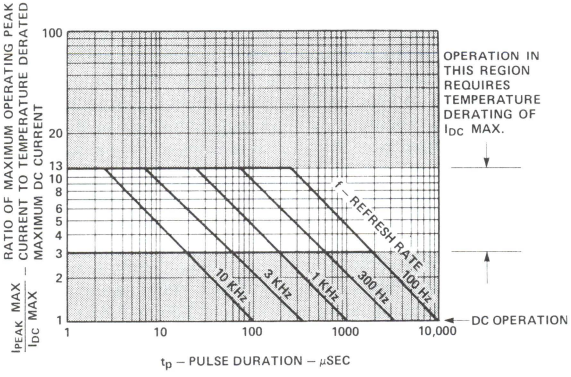


Figure 8. Allowed Peak Current vs. Pulse Duration — HDSP-7801 Series

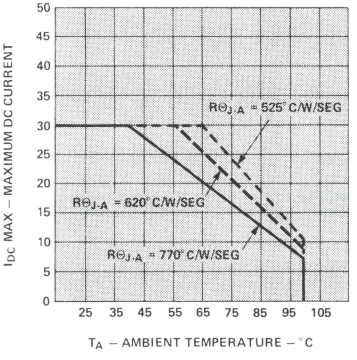


Figure 11. Maximum Allowable DC Current per Segment vs. Ambient Temperature — HDSP-7801 Series

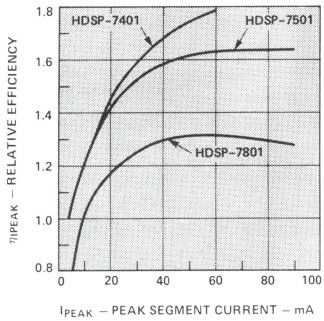


Figure 12. Relative Luminous Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

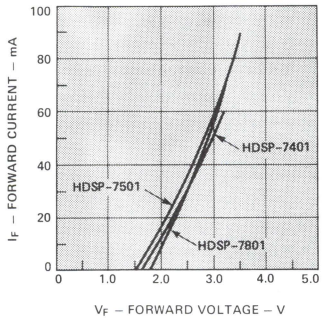


Figure 13. Forward Current vs. Forward Voltage Characteristics

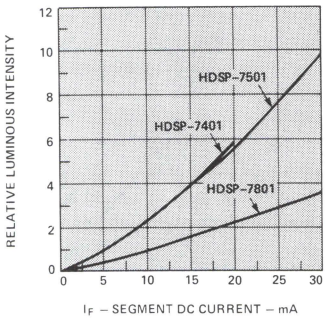


Figure 14. Relative Luminous Intensity vs. DC Forward Current

Electrical

The HDSP-7301/-7401/7501/-7801 series of display devices are composed of light emitting diodes, with the light from each LED optically stretched to form individual segments and decimal points. The -7301 series uses a p-n junction diffused into a GaAsP epitaxial layer on a GaAs substrate. The -7401 and -7501 series have their p-n junctions diffused into a GaAsP epitaxial layer on a GaP substrate. The -7801 series use a GaP epitaxial layer on GaP.

These display devices are well suited for strobed operation. The typical forward voltage values, scaled from Figure 4 or 13, should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F MAX models:

HDSP-7301 Series:

V_F MAX = 1.85 V + I_{PEAK} (7Ω)

For: $I_{PEAK} \geq 5$ mA

HDSP-7401/-7501 Series:

V_F MAX = 1.75 V + I_{PEAK} (38Ω)

For: $I_{PEAK} \geq 20$ mA

V_F MAX = 1.6 V + I_{DC} (45Ω)

For: 5 mA ≤ I_{DC} ≤ 20 mA

HDSP-7801 Series:

V_F MAX = 2.0 V + I_{PEAK} (50Ω)

For: $I_{PEAK} \geq 5$ mA

Contrast Enhancement

The objective of contrast enhancement is to provide good display readability in the end use ambient light. The concept is to employ both luminance and chrominance contrast techniques to enhance readability by having the OFF-segments blend into the display background and the ON-segments stand out vividly against this same background. Therefore, these display devices are assembled with a gray package and matching encapsulating epoxy in the segments.

Contrast enhancement may be achieved by using one of the following suggested filters:

HDSP-7301: Panelgraphic RUBY RED 60
SGL Homalite H100-1605 RED
3M Louvered Filter R6610 RED or N0210 GRAY

HDSP-7401: Panelgraphic YELLOW 27 or GRAY 10
SGL Homalite H100-1720 AMBER or -1266 GRAY
3M Louvered Filter A5910 AMBER or N0210 GRAY

HDSP-7501: Panelgraphic SCARLET RED 65 or GRAY 10
SGL Homalite H100-1670 RED or -1266 GRAY
3M Louvered Filter R6310 RED or N0210 GRAY

HDSP-7801: Panelgraphic GREEN 48
SGL Homalite H100-1440 GREEN
3M Louvered Filter G5610 GREEN or N0210 GRAY

Mechanical

To optimize device optical performance, specially developed plastics are used which restrict the solvents that may be used for cleaning. It is recommended that only mixtures of Freon (F113) and alcohol be used for vapor cleaning processes. with an immersion time in the vapors of less than two (2) minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolve DI-15 or DE-15, Arklone A or K. A 60°C (140°F) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and a thorough air dry. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, Ethanol, Isopropanol or water with a mild detergent.

Such cleaning agents from the ketone family (acetone, methyl ethyl ketone, etc.) and from the chlorinated hydrocarbon family (methylene chloride, trichloroethylene, carbon tetrachloride, etc.) are not recommended for cleaning LED parts. All of these various solvents attack or dissolve the encapsulating epoxies used to form the packages of plastic LED devices.

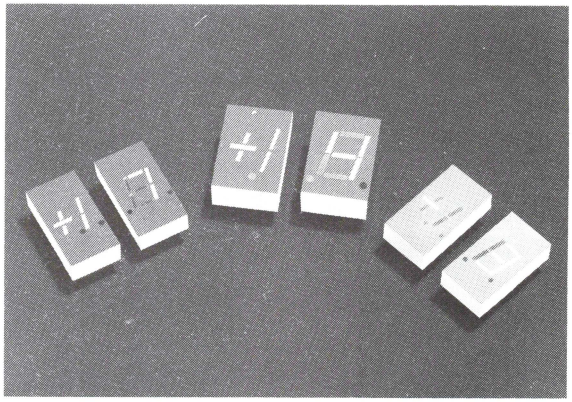
HEWLETT PACKARD

7.6/10.9 mm (0.3/0.43 INCH) SEVEN SEGMENT DISPLAYS

RED • 5082-7730/-7750 SERIES
HIGH EFFICIENCY RED • 5082-7610/-7650 SERIES
YELLOW • 5082-7620/-7660 SERIES
HIGH PERFORMANCE GREEN • HDSP-3600/-4600 SERIES

Features

- **COMPACT SIZE**
- **CHOICE OF 4 BRIGHT COLORS**
  Red
  High Efficiency Red
  Yellow
  High Performance Green
- **LOW CURRENT OPERATION**
  As Low as 3mA per Segment
  Designed for Multiplex Operation
- **EXCELLENT CHARACTER APPEARANCE**
  Evenly Lighted Segments
  Wide Viewing Angle
  Body Color Improves "Off" Segment Contrast
- **EASY MOUNTING ON PC BOARD OR SOCKETS**
  Industry Standard 7.62mm (0.3 in.) DIP Leads on 2.54mm (0.1 in.) Centers
- **CATEGORIZED FOR LUMINOUS INTENSITY; YELLOW AND GREEN CATEGORIZED FOR COLOR**
  Use of Like Categories Yields a Uniform Display
- **MECHANICALLY RUGGED**



Description

The -7730/-7610/-7620/-3600 and -7750/-7650/-7660/-4600 series are 7.62/10.92 mm (0.3/.43 in.) red, high efficiency red, yellow, and green displays. The -7730/-7610/-7620/-3600 series displays are designed for viewing distances of up to three metres and the -7750/-7650/-7660/-4600 series displays are designed for viewing distances of up to six metres. These displays are designed for use in instruments, point of sale terminals, clocks and appliances.

Devices

Part Number	Color	Description	Package Drawing
5082-7730	Red	7.6 mm Common Anode Left Hand Decimal	A
5082-7731		7.6 mm Common Anode Right Hand Decimal	B
5082-7740		7.6 mm Common Cathode Right Hand Decimal	C
5082-7736		7.6 mm Universal Overflow ±1 Right Hand Decimal	D
5082-7610	High Efficiency Red	7.6 mm Common Anode Left Hand Decimal	A
5082-7611		7.6 mm Common Anode Right Hand Decimal	B
5082-7613		7.6 mm Common Cathode Right Hand Decimal	C
5082-7616		7.6 mm Universal Overflow ±1 Right Hand Decimal	D
5082-7620	Yellow	7.6 mm Common Anode Left Hand Decimal	A
5082-7621		7.6 mm Common Anode Right Hand Decimal	B
5082-7623		7.6 mm Common Cathode Right Hand Decimal	C
5082-7626		7.6 mm Universal Overflow ±1 Right Hand Decimal	D
HDSP-3600	High Performance Green	7.6 mm Common Anode Left Hand Decimal	A
HDSP-3601		7.6 mm Common Anode Right Hand Decimal	B
HDSP-3603		7.6 mm Common Cathode Right Hand Decimal	C
HDSP-3606		7.6 mm Universal Overflow ±1 Right Hand Decimal	D

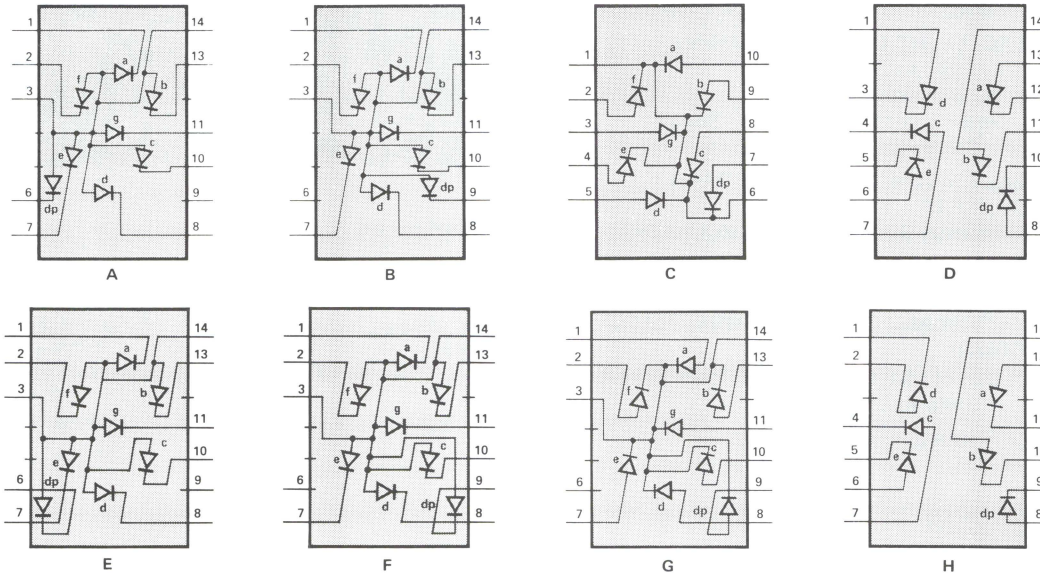
NOTE: Universal pinout brings the anode and cathode of each segment's LED out to separate pins. See internal diagram D.

Devices

Part Number	Color	Description	Package Drawing
5082-7750	Red	10.9 mm Common Anode Left Hand Decimal	E
5082-7751		10.9 mm Common Anode Right Hand Decimal	F
5082-7760		10.9 mm Common Cathode Right Hand Decimal	G
5082-7756		10.9 mm Universal Overflow ±1 Right Hand Decimal	H
5082-7650	High Efficiency Red	10.9 mm Common Anode Left Hand Decimal	E
5082-7651		10.9 mm Common Anode Right Hand Decimal	F
5082-7653		10.9 mm Common Cathode Right Hand Decimal	G
5082-7656		10.9 mm Universal Overflow ±1 Right Hand Decimal	H
5082-7660	Yellow	10.9 mm Common Anode Left Hand Decimal	E
5082-7661		10.9 mm Common Anode Right Hand Decimal	F
5082-7663		10.9 mm Common Cathode Right Hand Decimal	G
5082-7666		10.9 mm Universal Overflow ±1 Right Hand Decimal	H
HDSP-4600	High Performance Green	10.9 mm Common Anode Left Hand Decimal	E
HDSP-4601		10.9 mm Common Anode Right Hand Decimal	F
HDSP-4603		10.9 mm Common Cathode Right Hand Decimal	G
HDSP-4606		10.9 mm Universal Overflow ±1 Right Hand Decimal	H

NOTE: Universal pinout brings the anode and the cathode of each segment's LED out to separate pins, see internal diagram H.

Internal Circuit Diagram

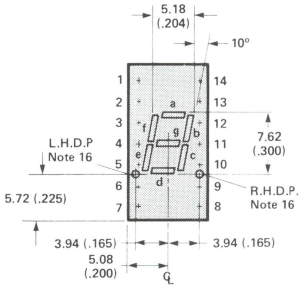


Absolute Maximum Ratings

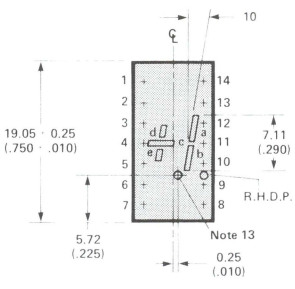
	-7730/-7750 Series	-7610/-7650 Series	-7620/-7660 Series	-3600/-4600 Series
Average Power Dissipation per Segment or DP	65 mW[1]	105 mW[2]	81 mW[3]	105 mW[4]
Operating Temperature Range	-40° C to +100° C	-40° C to +100° C	-40° C to +100° C	-40° C to +100° C
Storage Temperature	-55° C to +100° C	-55° C to +100° C	-55° C to +100° C	-55° C to +100° C
Peak Forward Current per Segment or DP	150 mA[5]	90 mA[6]	60 mA[7]	90 mA[8]
DC Forward Current per Segment or DP	25 mA[1]	30 mA[2]	20 mA[3]	30 mA[4]
Reverse Voltage per Segment or DP	3.0 V	3.0 V	3.0 V	3.0 V
Lead Soldering Temperature 1.59 mm (1/16 in.) below seating plane	260° C for 3 sec.	260° C for 3 sec.	260° C for 3 sec.	260° C for 3 sec.

Notes:
1. See power derating curve (Figure 5).
2. See power derating curve (Figure 6).
3. See power derating curve (Figure 7).
4. See power derating curve (Figure 8).
5. See Figure 1 to establish pulsed operating conditions.
6. See Figure 2 to establish pulsed operating conditions.
7. See Figure 3 to establish pulsed operating conditions.
8. See Figure 4 to establish pulsed operating conditions.

Package Dimensions (5082-7730/-7610/-7620/-3600)

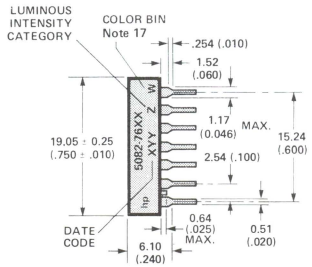


A,B,C

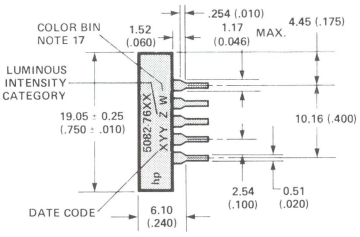


D

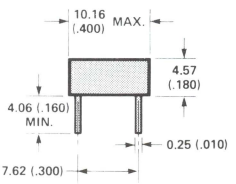
	FUNCTION			
PIN	A	B	C	D
1	CATHODE - a	CATHODE - a	NO PIN	ANODE - d
2	CATHODE - f	CATHODE - f	CATHODE[15]	NO PIN
3	ANODE[12]	ANODE[12]	ANODE - f	CATHODE - d
4	NO PIN	NO PIN	ANODE - g	CATHODE - c
5	NO PIN	NO PIN	ANODE - e	CATHODE - e
6	CATHODE - dp	NO CONN.[14]	ANODE - d	ANODE - e
7	CATHODE - e	CATHODE - e	NO PIN	ANODE - c
8	CATHODE - d	CATHODE - d	NO PIN	ANODE - dp
9	NO CONN.[14]	CATHODE - dp	CATHODE[15]	NO PIN
10	CATHODE - c	CATHODE - c	ANODE - dp	CATHODE - dp
11	CATHODE - g	CATHODE - g	ANODE - c	CATHODE - b
12	NO PIN	NO PIN	ANODE - b	CATHODE - a
13	CATHODE - b	CATHODE - b	ANODE - a	ANODE - a
14	ANODE[12]	ANODE[12]	NO PIN	ANODE - b



A,B,D SIDE

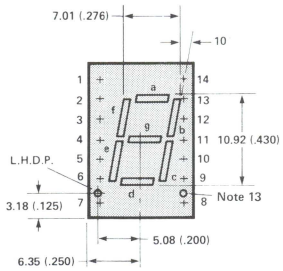


C SIDE

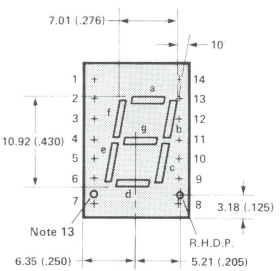


A,B,C,D END

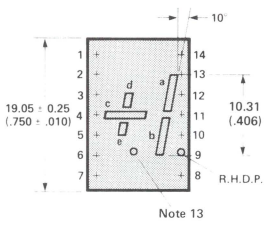
(5082-7750/-7650/-7660/-4600)



E

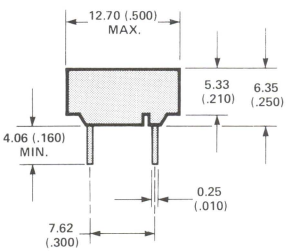


F,G

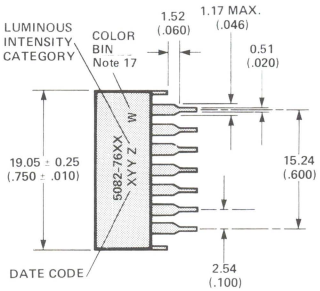


H

FRONT VIEW



END VIEW



SIDE VIEW

	FUNCTION			
PIN	E	F	G	H
1	CATHODE - a	CATHODE - a	ANODE - a	CATHODE - d
2	CATHODE - f	CATHODE - f	ANODE - f	ANODE - d
3	ANODE[12]	ANODE[12]	CATHODE[15]	NO PIN
4	NO PIN	NO PIN	NO PIN	CATHODE - c
5	NO PIN	NO PIN	NO PIN	CATHODE - e
6	CATHODE - dp	NO CONN.[14]	NO CONN.[14]	ANODE - e
7	CATHODE - e	CATHODE - e	ANODE - e	ANODE - c
8	CATHODE - d	CATHODE - d	ANODE - d	ANODE - dp
9	NO CONN.[14]	CATHODE - dp	ANODE - dp	CATHODE - dp
10	CATHODE - c	CATHODE - c	ANODE - c	CATHODE - b
11	CATHODE - g	CATHODE - g	ANODE - g	CATHODE - a
12	NO PIN	NO PIN	NO PIN	NO PIN
13	CATHODE - b	CATHODE - b	ANODE - b	ANODE - a
14	ANODE[12]	ANODE[12]	CATHODE[15]	ANODE - b

NOTES:
10. Dimensions in millimetres and (inches).
11. All untoleranced dimensions are for reference only.
12. Redundant anodes.
13. Unused dp position.
14. See Internal Circuit Diagram.
15. Redundant cathode.
16. See part number table for L.H.D.P. and R.H.D.P. designation.
17. For yellow and green devices only.

Electrical/Optical Characteristics at T_A=25°C

RED 5082-7730/-7750 SERIES

Parameter	Device HDSP-	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/ Segment[18] (Digit Average)	-7730 Series	I_V	20 mA DC	360	770		μcd
			100 mA Pk 1:10 Duty Factor		400		
	-7750 Series		20 mA DC	360	1100		
			100 mA Pk 1:10 Duty Factor		570		
Peak Wavelength		λ_{PEAK}			655		nm
Dominant Wavelength[19]		λ_d			640		nm
Forward Voltage/Segment or D.P.[21]		V_F	I_F = 20 mA		1.6	2.0	V
Reverse Voltage/Segment or D.P.[21,22]		V_R	I_R = 100 μA	3.0	30.0		V
Temperature Coefficient of V_F/Segment or D.P.		ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin		$R\theta_{J\text{-}PIN}$			282		° C/W/ Seg

HIGH EFFICIENCY RED 5082-7610/-7650 SERIES

Parameter	Device HDSP-	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/ Segment[18] (Digit Average)	-7610 Series	I_V	5 mA DC	340	800		μcd
			60 mA Pk 1:6 Duty Factor		2800		
	-7650 Series		5 mA DC	340	1115		
			60 mA Pk 1:10 Duty Factor		3900		
Peak Wavelength		λ_{PEAK}			635		nm
Dominant Wavelength[19]		λ_d			626		nm
Forward Voltage/Segment or D.P.[21]		V_F	I_F = 5 mA		1.7		
			I_F = 20 mA		2.0	2.5	V
			I_F = 60 mA		2.8		
Reverse Voltage/Segment or D.P.[21,22]		V_R	I_R = 100 μA	3.0	30.0		V
Temperature Coefficient of V_F/Segment or D.P.		ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin		$R\theta_{J\text{-}PIN}$			282		° C/W/ Seg

YELLOW 5082-7620/-7660 SERIES (continued)

Parameter	Device HDSP-	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/ Segment[18] (Digit Average)	-7620 Series	I_V	5 mA DC	205	620		μcd
			60 mA Pk 1:6 Duty Factor		2414		
	-7660 Series		5 mA DC	290	835		
			60 mA Pk 1:6 Duty Factor		3250		
Peak Wavelength		λ_{PEAK}			583		nm
Dominant Wavelength[19,20]		λ_d		581.5	586	592.5	nm
Forward Voltage/Segment or D.P.[21]		V_F	$I_F = 5$ mA		1.8		
			$I_F = 20$ mA		2.2	2.5	V
			$I_F = 60$ mA		3.1		
Reverse Voltage/Segment or D.P.[21,22]		V_R	$I_R = 100$ μA	3.0	50.0		V
Temperature Coefficient of V_F/Segment or D.P.		ΔV_F/° C			-2.0		mV/° C
Thermal Resistance LED Junction-to-Pin		$R\theta_{J\text{-}PIN}$			282		° C/W/ Seg

HIGH PERFORMANCE GREEN HDSP-3600/-4600 SERIES

Parameter	Device HDSP-	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/ Segment[18] (Digit Average)	-3600 Series	I_V	10 mA DC	570	1800		μcd
			60 mA Pk 1:6 Duty Factor		2350		
	-7750 Series		10 mA DC	460	1750		
			60 mA Pk 1:6 Duty Factor		2280		
Peak Wavelength		λ_{PEAK}			566		nm
Dominant Wavelength[19,20] (Digit Average)		λ_d			571	577	nm
Forward Voltage/Segment or D.P.[21]		V_F	$I_F = 10$ mA		2.1	2.5	V
Reverse Voltage/Segment or D.P.[21,22]		V_R	$I_R = 100$ μA	3.0	50.0		V
Thermal Resistance LED Junction-to-Pin		$R\theta_{J\text{-}PIN}$			282		° C/W/ Seg

NOTES:

18. The digits are categorized for luminous intensity with the intensity category designated by a letter located on the right hand side of the package.
19. The dominant wavelength, λ_d, is derived from the C.I.E. Chromaticity Diagram and is that single wavelength which defines the color of the device.
20. The displays are categorized as to dominant wavelength with the category designated by a number adjacent to the intensity category letter.
21. Quality level for electrical characteristics is 1000 parts per million.
22. Typical specification is for reference only. Do not exceed absolute maximum ratings.

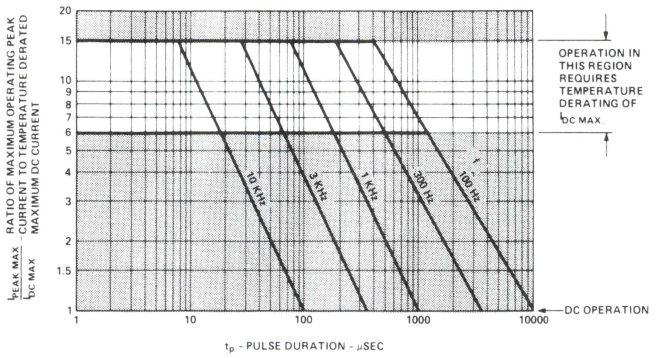


Figure 1. Maximum Tolerable Peak Current vs. Pulse Duration) 5082-7730/-7750 Series

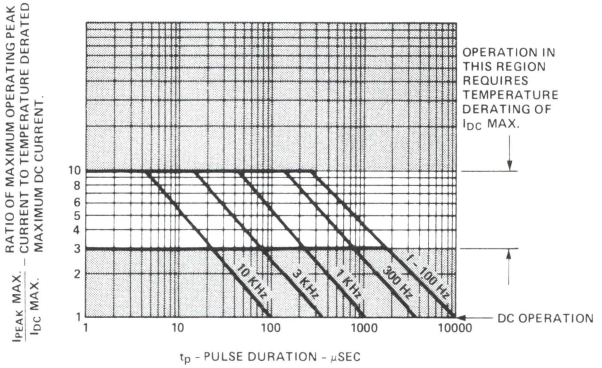


Figure 2. Maximum Tolerable Peak Current vs. Pulse Duration — 5082-7610/-7650 Series

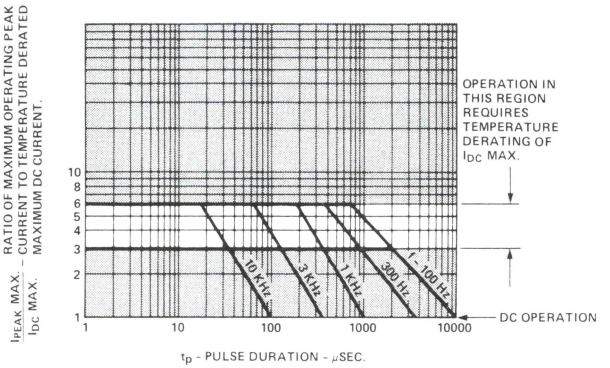


Figure 3. Maximum Tolerable Peak Current vs. Pulse Duration — 5082-7620/-7660 Series

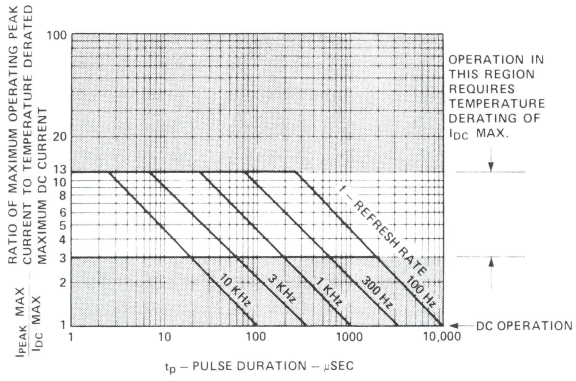


Figure 4. Allowed Peak Current vs. Pulse Duration — HDSP-3600/-4600 Series

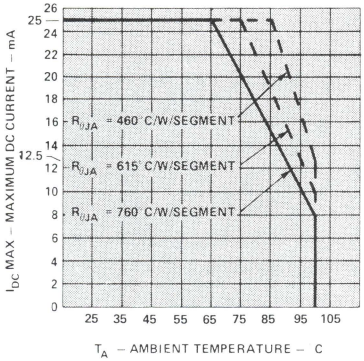


Figure 5. Maximum Allowable DC Current Dissipation per Segment as a Function of Ambient Temperature- 5082-7730/-7750 Series

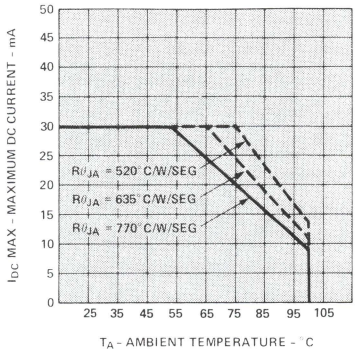


Figure 6. Maximum Allowable DC Current and DC Power Dissipation per Segment as a Function of Ambient Temperature — 5082-7610/-7650 Series

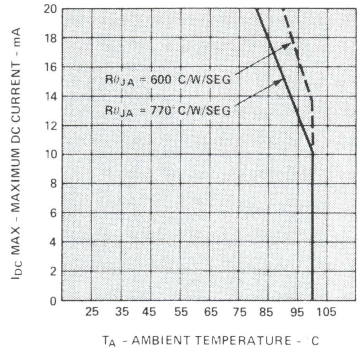


Figure 7. Maximum Allowable DC Current and DC Power Dissipation per Segment as a Function of Ambient Temperature — 5082-7620/-7660 Series

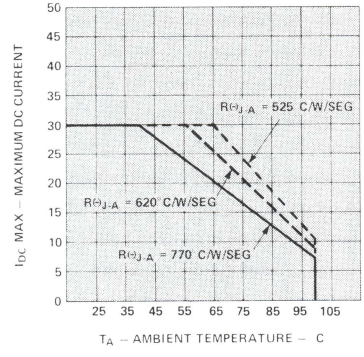


Figure 8. Maximum Allowable DC Current per Segment vs. Ambient Temperature — HDSP-3600/-4600 Series

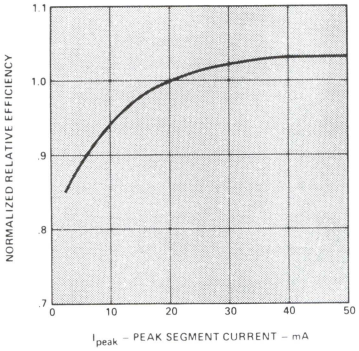


Figure 9. Relative Efficiency (Luminous Intensity per Unit Current) versus Peak Current per Segment- 5082-7730/-7750 Series

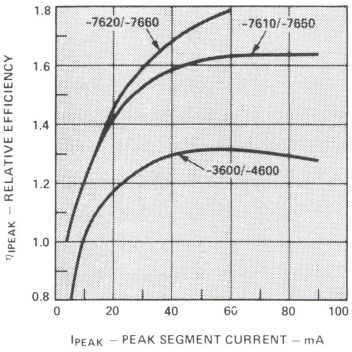


Figure 10. Relative Luminous Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

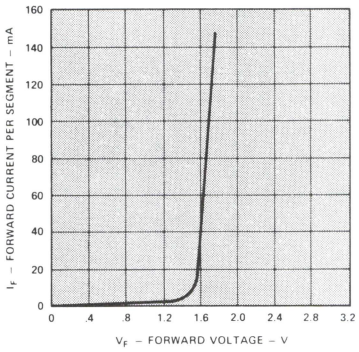


Figure 11. Forward Current vs. Forward Voltage- 5082-7730/-7750 Series.

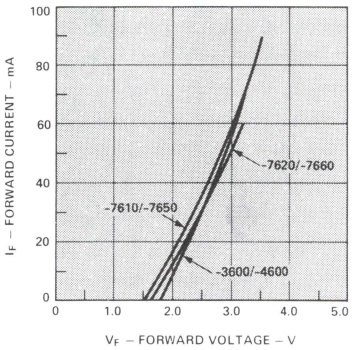


Figure 12. Forward Current vs. Forward Voltage Characteristics

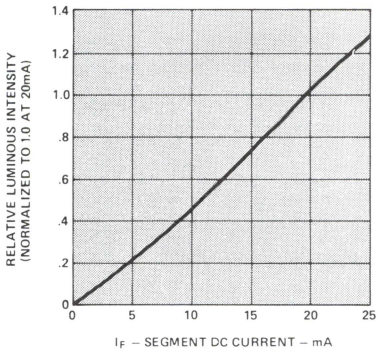


Figure 13. Relative Luminous Intensity vs. DC Forward Current- 5082-7730/-7750 Series

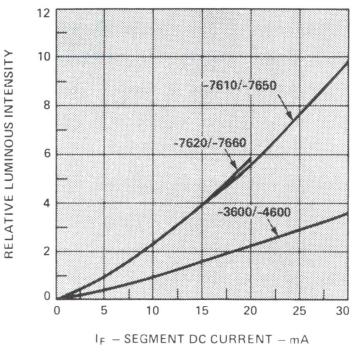


Figure 14. Relative Luminous Intensity vs. DC Forward Current

Electrical

These display devices are composed of light emitting diodes, with the light from each LED optically stretched to form individual segments and decimal points.

These display devices are well suited for strobed operation. The typical forward voltage values, scaled from Figure 8, should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F MAX models:

5082-7730/-7750 Series:

$V_F = 1.55V + I_{PEAK} (7\Omega)$

For 5 mA $\leq I_{PEAK} \leq$ 150 mA

5082-7610/-7620/-7650/-7660 Series:

V_F MAX = 1.75 V + I_{PEAK} (38Ω)

For: $I_{PEAK} \geq$ 20 mA

V_FMAX = 1.6 V + I_{DC} (45Ω)

For: 5 mA $\leq I_{DC} \leq$ 20 mA

HDSP-3600/-4600 Series:

V_F MAX = 2.0 V + I_{PEAK} (50Ω)

For: $I_{PEAK} \geq$ 5 mA

Contrast Enhancement

The objective of contrast enhancement is to provide good display readability in the end use ambient light. The concept is to employ both luminance and chrominance contrast techniques to enhance readability by having the OFF-segments blend into the display background and the ON-segments stand out vividly against this same background. Therefore, these display devices are assembled with a package color which matches the encapsulating epoxy in the segments.

Contrast enhancement may be achieved by using one of the following suggested filters:

5082-7730/ -7750	Panelgraphic RUBY RED 60 or GRAY 10 SGL Homalite H100-1605 RED or -1266 GRAY 3M Louvered Filter R6510 RED or N0210 GRAY
5082-7610/ -7650	Panelgraphic SCARLET RED 65 or GRAY 10 SGL Homalite H100-1670 RED or -1266 GRAY 3M Louvered Filter R6310 RED or N0210 GRAY
5082-7620/ -7660	Panelgraphic YELLOW 27 or GRAY 10 SGL Homalite H100-1720 AMBER or -1266 GRAY 3M Louvered Filter A5910 AMBER or N0210 GRAY
HDSP-3600/ -4600	Panelgraphic GREEN 48 SGL Homalite H100-1440 GREEN 3M Louvered Filter G5610 GREEN or N0210 GRAY

Mechanical

To optimize device optical performance, specially developed plastics are used which restrict the solvents that may be used for cleaning. It is recommended that only mixtures of Freon (F113) and alcohol be used for vapor cleaning processes. with an immersion time in the vapors of less than two (2) minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolve DI-15 or DE-15, Arklone A or K. A 60°C (140°F) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and a thorough air dry. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, Ethanol, Isopropanol or water with a mild detergent.

Such cleaning agents from the ketone family (acetone, methyl ethyl ketone, etc.) and from the chlorinated hydrocarbon family (methylene chloride, trichloroethylene, carbon tetrachloride, etc.) are not recommended for cleaning LED parts. All of these various solvents attack or dissolve the encapsulating epoxies used to form the packages of plastic LED devices.

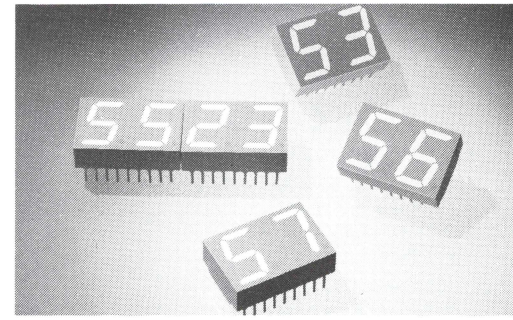
HEWLETT PACKARD

14.2mm (.56 INCH) SEVEN SEGMENT DISPLAYS

RED	HDSP-5301 SERIES
HIGH EFFICIENCY RED	HDSP-5501 SERIES
HIGH PERFORMANCE GREEN	HDSP-5601 SERIES
YELLOW	HDSP-5701 SERIES

Features

- **INDUSTRY STANDARD SIZE**
- **INDUSTRY STANDARD PINOUT**
  15.24mm (.6 inch) DIP Leads on
  2.54mm (.1 inch) Centers
- **CHOICE OF FOUR COLORS**
  Red **Yellow**
  High-Efficiency Red **High Performance Green**
- **EXCELLENT CHARACTER APPEARANCE**
  Evenly Lighted Segments
  Mitered Corners on Segments
  Gray Package Gives Optimum Contrast
- **COMMON ANODE OR COMMON CATHODE**
  Right Hand Decimal Point
  Overflow ±1 Character
- **CATEGORIZED FOR LUMINOUS INTENSITY; YELLOW AND GREEN CATEGORIZED FOR COLOR**
  Use of Like Categories Yields a Uniform Display



Description

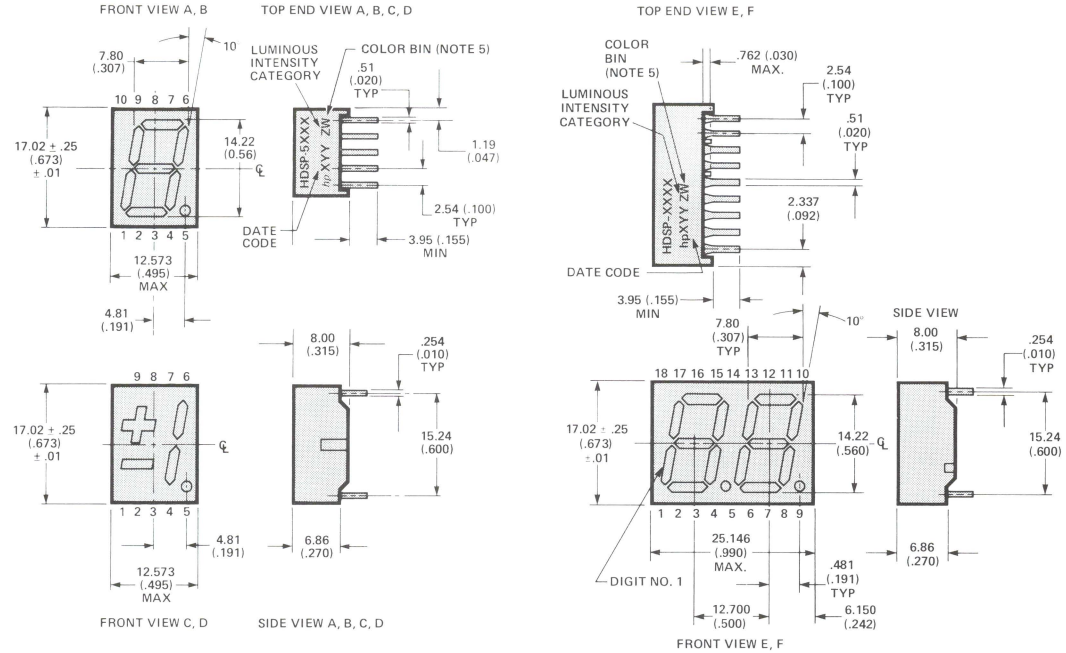
The HDSP-5301/-5501/-5601/-5701 Series are large 14.22 mm (.56 inch) LED seven segment displays. Designed for viewing distances up to 7 metres (23 feet), these displays provide excellent readability in bright ambients.

These devices utilize an industry standard size package and pin function configuration. Both the numeric and ±1 overflow devices feature a right hand decimal point and are available as either common anode or common cathode.

Devices

Part No. HDSP-	Color	Description	Package Drawing
5301		Common Anode Right Hand Decimal	A
5303		Common Cathode Right Hand Decimal	B
5307	Red	Overflow ±1 Common Anode	C
5308		Overflow ±1 Common Cathode	D
5321		Two Digit Common Anode Right Hand Decimal	E
5323		Two Digit Common Cathode Right Hand Decimal	F
5501		Common Anode Right Hand Decimal	A
5503		Common Cathode Right Hand Decimal	B
5507	High Efficiency	Overflow ±1 Common Anode	C
5508	Red	Overflow ±1 Common Cathode	D
5521		Two Digit Common Anode Right Hand Decimal	E
5523		Two Digit Common Cathode Right Hand Decimal	F
5601		Common Anode Right Hand Decimal	A
5603		Common Cathode Right Hand Decimal	B
5607	High Performance	Overflow ±1 Common Anode	C
5608	Green	Overflow ±1 Common Cathode	D
5621		Two Digit Common Anode Right Hand Decimal	E
5623		Two Digit Common Cathode Right Hand Decimal	F
5701		Common Anode Right Hand Decimal	A
5703		Common Cathode Right Hand Decimal	B
5707	Yellow	Overflow ±1 Common Anode	C
5708		Overflow ±1 Common Cathode	D
5721		Two Digit Common Anode Right Hand Decimal	E
5723		Two Digit Common Cathode Right Hand Decimal	F

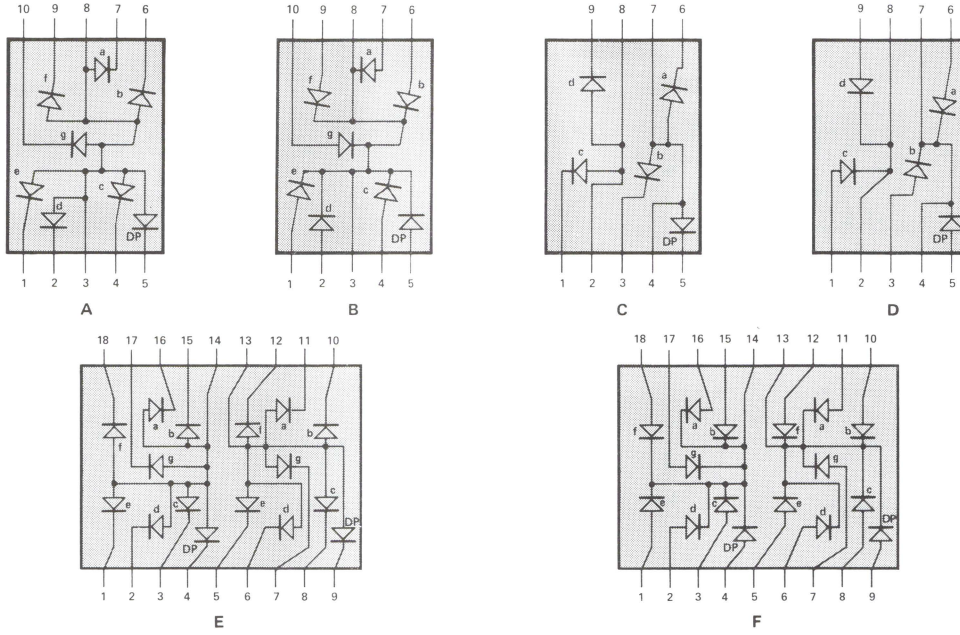
Package Dimensions



PIN	FUNCTION					
	A	B	C	D	E	F
1	CATHODE e	ANODE e	CATHODE c	ANODE c	E CATHODE NO. 1	E ANODE NO. 1
2	CATHODE d	ANODE d	ANODE c, d	CATHODE c, d	D CATHODE NO. 1	D ANODE NO. 1
3	ANODE[3]	CATHODE[4]	CATHODE b	ANODE b	C CATHODE NO. 1	C ANODE NO. 1
4	CATHODE c	ANODE c	ANODE a, b, DP	CATHODE a, b, DP	DP CATHODE NO. 1	DP ANODE NO. 1
5	CATHODE DP	ANODE DP	CATHODE DP	ANODE DP	E CATHODE NO. 2	E ANODE NO. 2
6	CATHODE b	ANODE b	CATHODE a	ANODE a	D CATHODE NO. 2	D ANODE NO. 2
7	CATHODE a	ANODE a	ANODE a, b, DP	CATHODE a, b, DP	G CATHODE NO. 2	G ANODE NO. 2
8	ANODE[3]	CATHODE[4]	ANODE c, d	CATHODE c, d	C CATHODE NO. 2	C ANODE NO. 2
9	CATHODE f	ANODE f	CATHODE d	ANODE d	DP CATHODE NO. 2	DP ANODE NO. 2
10	CATHODE g	ANODE g	NO PIN	NO PIN	B CATHODE NO. 2	B ANODE NO. 2
11					A CATHODE NO. 2	A ANODE NO. 2
12					F CATHODE NO. 2	F ANODE NO. 2
13					DIGIT NO. 2 ANODE	DIGIT NO. 2 CATHODE
14					DIGIT NO. 1 ANODE	DIGIT NO. 1 CATHODE
15					B CATHODE NO. 1	B ANODE NO. 1
16					A CATHODE NO. 1	A ANODE NO. 1
17					G CATHODE NO. 1	G ANODE NO. 1
18					F CATHODE NO. 1	F ANODE NO. 1

Notes:
1. All dimensions in millimetres (inches).
2. All untoleranced dimensions are for reference only.
3. Redundant anodes.
4. Redundant cathodes.
5. For HDSP-5601/-5701 series product only.

Internal Circuit Diagram



Absolute Maximum Ratings

	-5301 Series	-5501 Series	-5601 Series	-5701 Series
Average Power per Segment or DP	60 mW	105 mW	105 mW	80 mW
Peak Forward Current per Segment or DP	150 mA[6] (Pulse Width ≤ .2 ms)	90 mA[7] (Pulse Width ≤ 1 ms)	90 mA[7] (Pulse Width ≤ 1 ms)	60 mA[8] (Pulse Width ≤ 1 ms)
DC Forward Current per Segment[9] or DP	25 mA	30 mA	30 mA	20 mA
Operating Temperature Range	-40° C to +100° C	-40° C to +100° C	-40° C to +100° C	-40° C to +100° C
Storage Temperature Range	-55° C to +100° C	-55° C to +100° C	-55° C to +100° C	-55° C to +100° C
Reverse Voltage per Segment or DP	3.0V	3.0V	3.0V	3.0V
Lead Solder Temperature	260° C for 3 sec.	260° C for 3 sec. (1.59 mm | 1/16 in.| below seating plane)	260° for 3 sec.	260° for 3 sec.

Notes:

6. See Figure 1 to establish pulsed operating conditions.
7. See Figure 6 to establish pulsed operating conditions. HDSP-5501. See Figure 7 to establish pulsed operating conditions. HDSP-5601.
8. See Figure 8 to establish pulsed operating conditions.
9. Derate Maximum DC current: See Figure 2 for -5301 Series. See Figure 9 for -5501 Series. See Figure 10 for -5601 Series. See Figure 11 for -5701 Series.

Electrical/Optical Characteristics at $T_A = 25°C$

RED HDSP-5301 Series

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[10] (Digit Average)	I_V	$I_F = 20$ mA	600	1300		μcd
		100 mA Peak: 1 of 5 Duty Factor		1400		
Peak Wavelength	λ_{PEAK}			655		nm
Dominant Wavelength[11]	λ_d			640		nm
Forward Voltage/Segment or DP[12]	V_F	$I_F = 20$ mA		1.6	2.0	V
Reverse Voltage/Segment or DP[12, 17]	V_R	$I_R = 100$ μA	3	12		V
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			345		°C/W/ Seg.

Notes:

10. The digits are categorized for luminous intensity with category designated by a letter located on the right hand side of the package. The luminous intensity minimum and categories are determined by computing the numerical average of the individual segment intensities, decimal point not included.
11. The dominant wavelength, λ_d, is derived from the C.I.E. Chromaticity Diagram and is that single wavelength which defines the color of the device.
12. Quality level for Electrical Characteristics is 1000 parts per million.

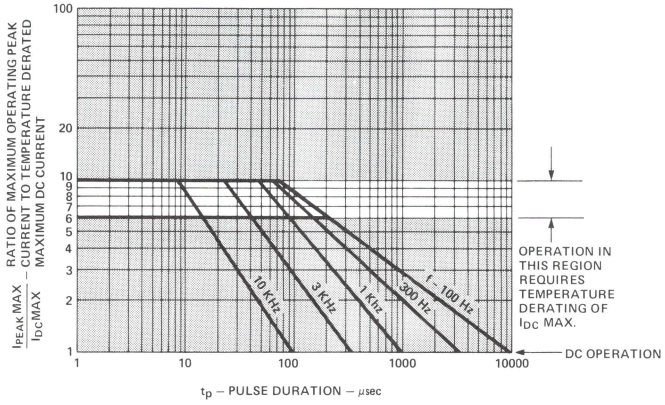


Figure 1. Maximum Tolerable Peak Current vs. Pulse Duration.

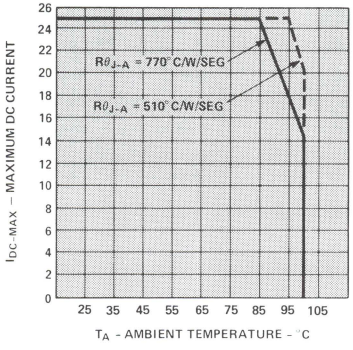


Figure 2. Maximum Allowable Average Forward Current Per Segment vs. Ambient Temperature. HDSP-5301 Series.

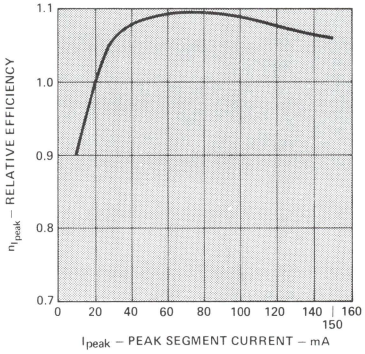


Figure 3. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current.

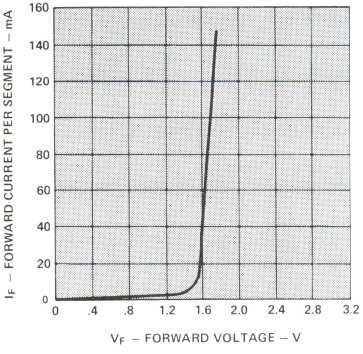


Figure 4. Forward Current vs. Forward Voltage.

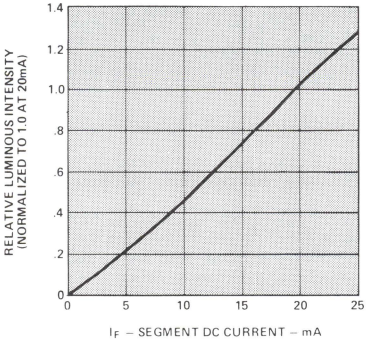


Figure 5. Relative Luminous Intensity vs. D.C. Forward Current.

For a Detailed Explanation of the Use of Data Sheet Information and Recommended Soldering Procedures, See Application Note 1005.

HIGH EFFICIENCY RED HDSP-5501 SERIES

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[13] (Digit Average)	I_V	10 mA DC	900	2800		µcd
		60 mA Peak: 1 of 6 Duty Factor		3700		
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength[14]	λ_d			626		nm
Forward Voltage/Segment or DP[16]	V_F	I_F = 20 mA		2.1	2.5	V
Reverse Voltage/Segment or DP[17]	V_R	I_R = 100 µA	3	30		V
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			345		°C/W/ Seg.

HIGH PERFORMANCE GREEN HDSP-5601 SERIES

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[13] (Digit Average)	I_V	10 mA DC	900	2500		µcd
		60 mA Peak: 1 of 6 Duty Factor		3100		
Peak Wavelength	λ_{PEAK}			566		nm
Dominant Wavelength[14, 15]	λ_d			571	577	nm
Forward Voltage/Segment or DP[16]	V_F	I_F = 10 mA		2.1	2.5	V
Reverse Voltage/Segment or DP[16, 17]	V_R	I_R = 100 µA	3	50		V
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			345		°C/W/ Seg.

YELLOW HDSP-5701 SERIES

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment[13] (Digit Average)	I_V	10 mA DC	600	1800		µcd
		60 mA Peak: 1 of 6 Duty Factor		2700		
Peak Wavelength	λ_{PEAK}			583		nm
Dominant Wavelength[14, 15]	λ_d		581.5	586	592.5	nm
Forward Voltage/Segment or DP[16]	V_F	I_F = 20 mA		2.2	2.5	V
Reverse Voltage/Segment or DP[16, 17]	V_R	I_R = 100 µA	3	40		V
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			345		°C/W/ Seg.

Notes:

13. The digits are categorized for luminous intensity with category designated by a letter located on top of the package. The luminous intensity minimum and categories are determined by computing the numerical average of the individual segment intensities, decimal point not included.
14. The dominant wavelength, λ_d, is derived from the C.I.E. Chromaticity Diagram and is that single wavelength which defines the color of the device.
15. The HDSP-5601 and HDSP-5701 series displays are categorized as to dominant wavelength with the category designated by a number adjacent to the intensity category letter.
16. Quality level for Electrical Characteristics is 1000 parts per million.
17. Typical specification for reference only. Do not exceed absolute maximum ratings.

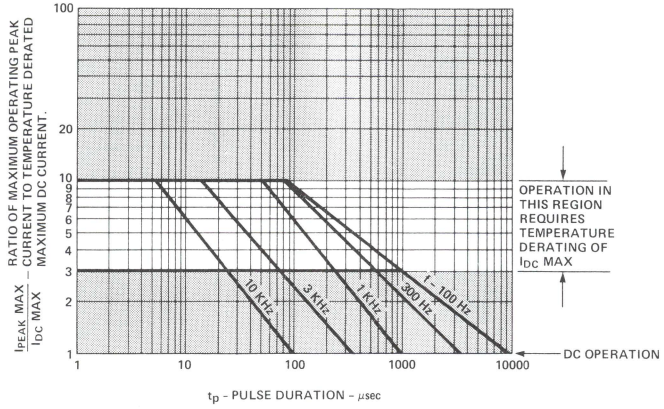


Figure 6. Maximum Tolerable peak Current vs. Pulse Duration — HDSP-5501 Series.

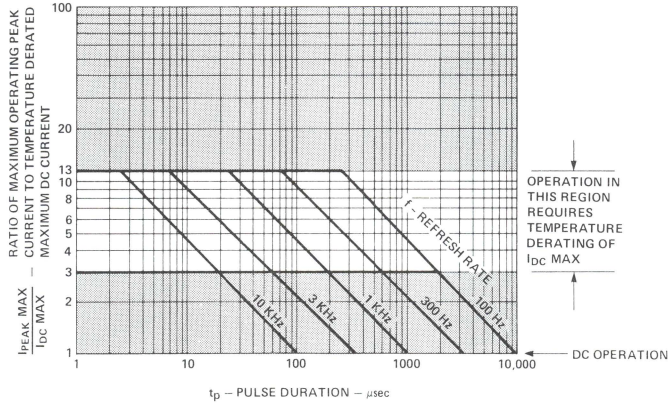


Figure 7. Maximum Tolerable peak Current vs. Pulse Duration — HDSP-5601 Series.

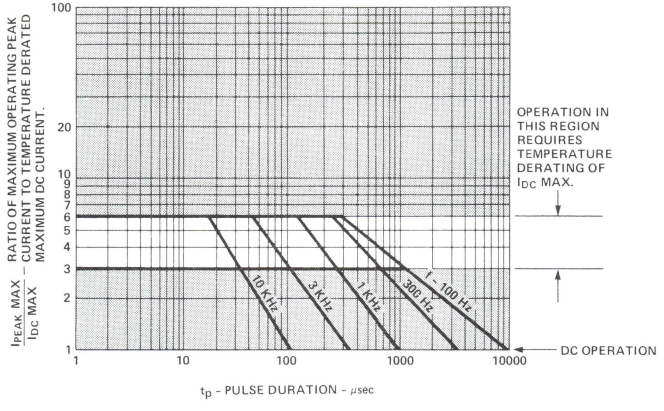


Figure 8. Maximum Tolerable peak Current vs. Pulse Duration — HDSP-5701 Series.

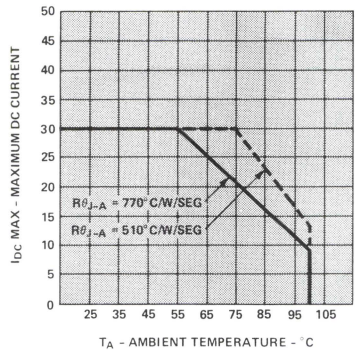


Figure 9. Maximum Allowable Average Current per Segment vs. Ambient Temperature. — HDSP-5501 Series.

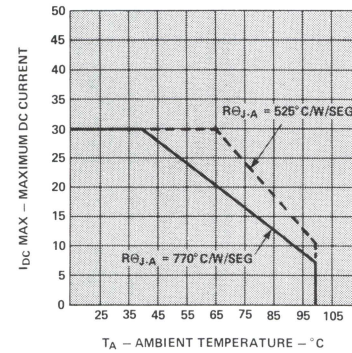


Figure 10. Maximum Allowable Average Current per Segment vs. Ambient Temperature. — HDSP-5601 Series.

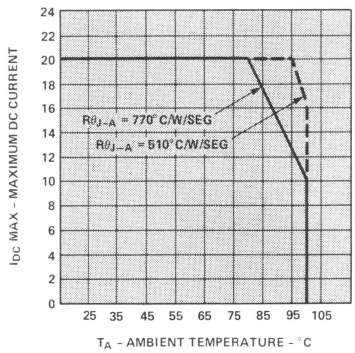


Figure 11. Maximum Allowable Average Current per Segment vs. Ambient Temperature. — HDSP-5701 Series.

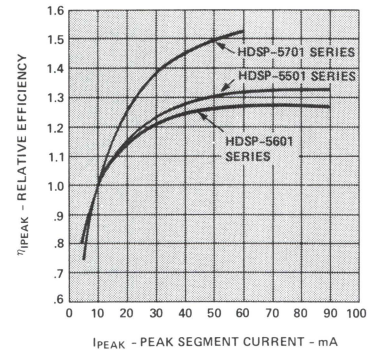


Figure 12. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current.

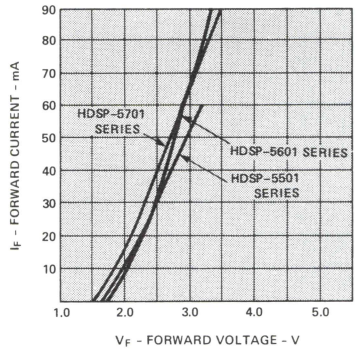


Figure 13. Forward Current vs. Forward Voltage Characteristics.

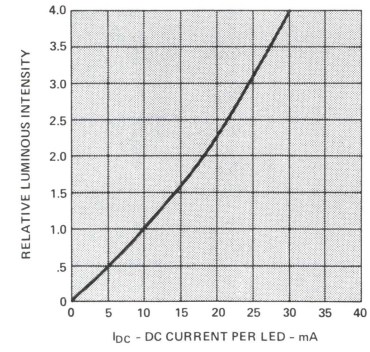


Figure 14. Relative Luminous Intensity vs. DC Forward Current. — HDSP-5501/-5601/-5701

Electrical

The HDSP-5301/-5501/-5601/-5701 series of display devices are composed of light emitting diodes, with the light from each LED optically stretched to form individual segments and decimal points. The -5301 series uses a p-n junction diffused into a GaAsP epitaxial layer on a GaAs substrate. The -5501 and -5701 series have their p-n junctions diffused into a GaAsP epitaxial layer on a GaP substrate. The -5601 series use a GaP epitaxial layer on GaP.

These display devices are designed for strobed operation. The typical forward voltage values, scaled from Figure 4 or 13, should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F MAX models:

HDSP-5301 Series:

V_F MAX = 1.55V + I_{PEAK} (7Ω)
For: $I_{PEAK} \geq 5$ mA

HDSP-5501/-5701 Series:

V_F MAX = 1.75V + I_{PEAK} (38Ω)
For: $I_{PEAK} \geq 20$ mA
V_F MAX = 1.5V + I_{DC} (45Ω)
For: 5 mA ≤ I_{DC} ≤ 20 mA

HDSP-5601 Series:

V_F MAX = 2.0V + I_{PEAK} (50Ω)
For: $I_{PEAK} \geq 5$ mA

Contrast Enhancement

The objective of contrast enhancement is to provide good display readability in the end use ambient light. The concept is to employ both luminance and chrominance contrast techniques to enhance readibility by having the OFF-segments blend into the display background and the ON-segments stand out vividly against this same background. Therefore, these display devices are assembled with a gray package and matching encapsulating epoxy in the segments.

Contrast enhancement may be achieved by using one of the following suggested filters:

HDSP-5301: Panelgraphic RUBY RED 60
SGL Homalite H100-1605 RED
3M Louvered Filter R6610 RED or N0210 GRAY

HDSP-5501: Panelgrahpic SCARLET RED 65 or GRAY 10
SGL Homalite H100-1670 RED or -1266 GRAY
3M Louvered Filter R6310 RED or N0210 GRAY

HDSP-5601: Panelgraphic GREEN 48
SGL Homalite H100-1440 GREEN
3M Louvered Filter G5610 GREEN or N0210 GRAY

HDSP-5701: Panelgraphic YELLOW 27 or GRAY 10
SGL Homalite H100-1720 AMBER or -1266 GRAY
3M Louvered Filter A5910 AMBER or N0210 GRAY

Mechanical

To optimize device optical performance, specially developed plastics are used which restrict the solvents that may be used for cleaning. It is recommended that only mixtures of Freon (F113) and alcohol be used for vapor cleaning processes, with an immersion time in the vapors of less than two (2) minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolve DI-15 or DE-15. Arklone A or K. A 60°C (140°F) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and a thorough air dry. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, Ethanol, Isopropanol or water with a mild detergent.

Such cleaning agents from the ketone family (acetone, methyl ethyl ketone, etc.) and from the chlorinated hydrocarbon family (methylene chloride, trichloroethylene, carbon tetrachloride, etc.) are not recommended for cleaning LED parts. All of these various solvents attack or dissolve the encapsulating epoxies used to form the packages of plastic LED devices.

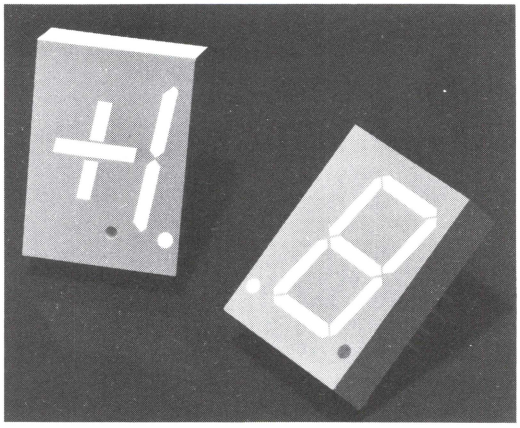
HEWLETT PACKARD

LARGE 20 mm (0.8") SEVEN SEGMENT DISPLAYS

RED HDSP-3400 Series
HIGH EFFICIENCY RED HDSP-3900 Series
YELLOW HDSP-4200 Series
HIGH PERFORMANCE GREEN HDSP-8600 Series

Features

- **20 mm (0.8") DIGIT HEIGHT**
  Viewable Up to 10 Metres (33 Feet)
- **CHOICE OF FOUR COLORS**
  Red Yellow
  High Efficiency Red Green
- **EXCELLENT CHARACTER APPEARANCE**
  Evenly Lighted Segments
  Wide Viewing Angle
  Mitered Corners on Segments
  Grey Package Provides Optimum Contrast
- **CATEGORIZED FOR LUMINOUS INTENSITY; YELLOW AND GREEN CATEGORIZED FOR COLOR**
  Use of Like Categories Yields a Uniform Display
- **IC COMPATIBLE**
- **MECHANICALLY RUGGED**



Description

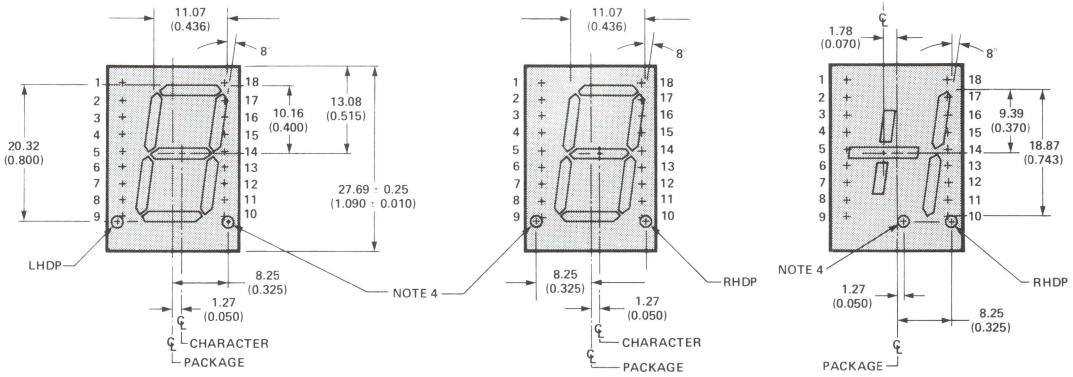
The HDSP-3400/-3900/-4200/-8600 Series are very large 20 mm (0.8 in.) LED seven segment displays. Designed for viewing distances up to 10 metres (33 feet), these single digit displays provide excellent readability.

These devices utilize a standard 15.24 mm (0.6 in.) dual in line package configuration that permits mounting on PC boards or in standard IC sockets. Requiring a low forward voltage, these displays are inherently IC compatible, allowing for easy integration into electronic instrumentation, point-of-sale terminals, TVs, weighing scales, and digital clocks.

Devices

Part Number	Color	Description	Package Drawing
HDSP-3400	Red	Common Anode Left Hand Decimal	A
HDSP-3401		Common Anode Right Hand Decimal	B
HDSP-3403		Common Cathode Right Hand Decimal	C
HDSP-3405		Common Cathode Left Hand Decimal	D
HDSP-3406		Universal Overflow ±1 Right Hand Decimal	E
HDSP-3900	High Efficiency Red	Common Anode Left Hand Decimal	A
HDSP-3901		Common Anode Right Hand Decimal	B
HDSP-3903		Common Cathode Right Hand Decimal	C
HDSP-3905		Common Cathode Left Hand Decimal	D
HDSP-3906		Universal Overflow ±1 Right Hand Decimal	E
HDSP-4200	Yellow	Common Anode Left Hand Decimal	A
HDSP-4201		Common Anode Right Hand Decimal	B
HDSP-4203		Common Cathode Right Hand Decimal	C
HDSP-4205		Common Cathode Left Hand Decimal	D
HDSP-4206		Universal Overflow ±1 Right Hand Decimal	E
HDSP-8600	High Performance Green	Common Anode Left Hand Decimal	A
HDSP-8601		Common Anode Right Hand Decimal	B
HDSP-8603		Common Cathode Right Hand Decimal	C
HDSP-8605		Common Cathode Left Hand Decimal	D
HDSP-8606		Universal Overflow ±1	E

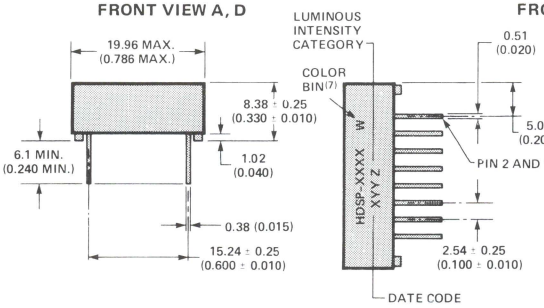
Package Dimensions (3900/4200 Series)



FRONT VIEW A, D

FRONT VIEW B, C

FRONT VIEW E



END VIEW

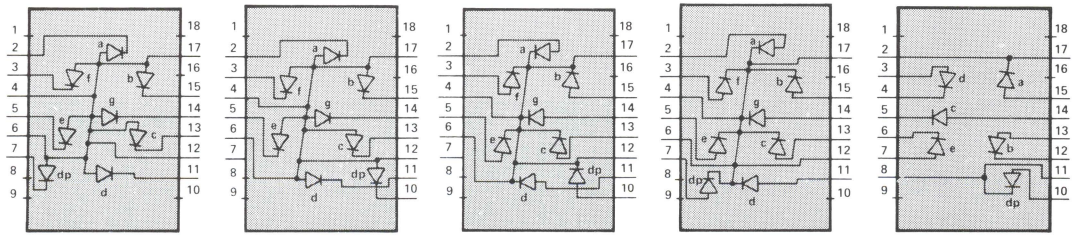
SIDE VIEW

Pin	Function A 3400/3900/4200/8600	B 3401/3901/4201/8601	C 3403/3903/4203/8603	D 3405/3905/4205/8605	E 3406/3906/4206/8606
1	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
2	CATHODE a	CATHODE a	ANODE a	ANODE a	CATHODE a
3	CATHODE f	CATHODE f	ANODE f	ANODE f	ANODE d
4	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE d
5	CATHODE e	CATHODE e	ANODE e	ANODE e	CATHODE c
6	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE e
7	CATHODE dp	NO. CONNEC.	NO. CONNEC.	ANODE dp	ANODE e
8	NO PIN	NO PIN	NO PIN	NO PIN	CATHODE dp
9	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
10	NO PIN	CATHODE dp	ANODE dp	NO PIN	ANODE dp
11	CATHODE d	CATHODE d	ANODE d	ANODE d	CATHODE dp
12	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE b
13	CATHODE c	CATHODE c	ANODE c	ANODE c	ANODE b
14	CATHODE g	CATHODE g	ANODE g	ANODE g	ANODE c
15	CATHODE b	CATHODE b	ANODE b	ANODE b	ANODE a
16	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
17	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE a
18	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN

NOTES:

1. Dimensions in millimeters and (inches).
2. All untoleranced dimensions are for reference only.
3. Redundant anodes.
4. Unused dp position.
5. See Internal Circuit Diagram.
6. Redundant Cathodes.
7. For HDSP-4200/-8600 Series product only.
8. See part number table for LHDP and RHDP designation.

Internal Circuit Diagram



A B C D E

Absolute Maximum Ratings

	-3400 Series	-3900/-4200 Series	-8600 Series
Average Power per Segment or DP (T_A = 25° C)[9]	120 mW	105 mW	105 mW
Operating Temperature Range[10]	−40° C to +85° C	−40° C to +85° C	−20° C to +85° C
Storage Temperature Range	−55° C to +100° C	−55° C to +100° C	−55° C to +100° C
Peak Forward Current per Segment or DP (T_A = 25° C, Pulse Width = 1.2 ms)[11]	200 mA	135 mA	90 mA
DC Forward Current per Segment or DP (T_A = 25° C)[9]	50 mA	40 mA	30 mA
Reverse Voltage per Segment or DP	3.0 V	3.0 V	3.0 V
Lead Soldering Temperature (1.6 mm [1/6 in.] Below Seating Plane)	260° C for 3 sec.	260° C for 3 sec.	260° C for 3 sec.

Notes:

9. See Power Derating Curves (see Figure 2 for -3400 Series, Figure 7 for -3900/-4200 Series, and Figure 12 for -8600 Series).
10. For operation of -8600 series to -40° C consult Optoelectronics division.
11. See appropriate curves to establish pulsed operating conditions (see Figure 1 for -3400 Series, Figure 6 for -3900/-4200 Series, Figure 11 for -8600 Series).

Electrical/Optical Characteristics at $T_A = 25°C$

RED HDSP-3400 SERIES

Description	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment (Digit Average)[12,13]	I_V	$I_F = 20$ mA	500	1200		μcd
Peak Wavelength	λ_{PEAK}			655		nm
Dominant Wavelength[14]	λ_d			640		nm
Forward Voltage, any Segment or DP[16]	V_F	$I_F = 20$ mA		1.6	2.0	V
Reverse Voltage, any Segment or DP[15,16]	V_R	$I_R = 100$ μA	3.0	20.0		V
Temperature Coefficient of Forward Voltage	$\Delta V_F/°C$	$I_F = 20$ mA		−1.5		mV/°C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			375		°C/W/ Seg

HIGH EFFICIENCY RED HDSP-3900 SERIES

Description	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment (Digit Average)[12,13]	I_V	100 mA Pk; 1 of 5 Duty Factor	3350	7000		μcd
		20 mA DC		4800		
Peak Wavelength	λ_{PEAK}			635		nm
Dominant Wavelength[14] (Digit Average)	λ_d			626		nm
Forward Voltage, any Segment or DP[16]	V_F	$I_F = 100$ mA		2.6	3.5	V
Reverse Voltage, any Segment or DP[16,17]	V_R	$I_R = 100$ μA	3.0	25.0		V
Temperature Coefficient of Forward Voltage	$\Delta V_F/°C$	$I_F = 100$ mA		−1.1		mV/°C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			375		°C/W/ Seg

YELLOW HDSP-4200 SERIES

Description	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment (Digit Average)[12,13]	I_V	100 mA Pk; 1 of 5 Duty Factor	2200	7000		μcd
		20 mA DC		3400		
Peak Wavelength	λ_{PEAK}			583		nm
Dominant Wavelength[14,15] (Digit Average)	λ_d		581.5	586	592.5	nm
Forward Voltage, any Segment or DP[16]	V_F	$I_F = 100$ mA		2.6	3.5	V
Reverse Voltage, any Segment or DP[16,17]	V_R	$I_R = 100$ μA	3.0	25.0		V
Temperature Coefficient of Forward Voltage	$\Delta V_F/°C$	$I_F = 100$ mA		−1.1		mV/°C
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			375		°C/W/ Seg

HIGH PERFORMANCE GREEN HDSP-8600 SERIES

Description	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment (Digit Average)[12,13]	I_V	60 mA Pk; 1 of 5 Duty Factor		1960		μcd
		10 mA DC	700	1500		
Peak Wavelength	λ_{PEAK}			566		nm
Dominant Wavelength[14,15] (Digit Average)	λ_d			571	577	nm
Forward Voltage, any Segment or DP[16]	V_F	I_F = 10 mA		2.1	2.5	V
Reverse Voltage, any Segment or DP[16,17]	V_R	I_R = 100 μA	3.0	50.0		V
Thermal Resistance LED Junction-to-Pin	$R\theta_{J-PIN}$			375		°C/W/ Seg

Notes:

12. Case temperature of the device immediately prior to the intensity measurement is 25° C.
13. The digits are categorized for luminous intensity with the intensity category designated by a letter on the side of the package.
14. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and is that single wavelength which defines the color of the device.
15. The yellow and green displays are categorized as to dominant wavelength with the category designated by a number adjacent to the intensity category letter.
16. Quality level for electrical characteristics is 1000 parts per million.
17. Typical specification for reference only. Do not exceed absolute maximum ratings.

HDSP-3400 SERIES

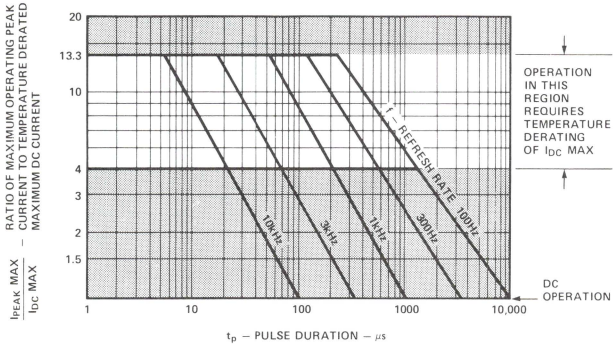


Figure 1. Maximum Allowable Peak Current vs. Pulse Duration

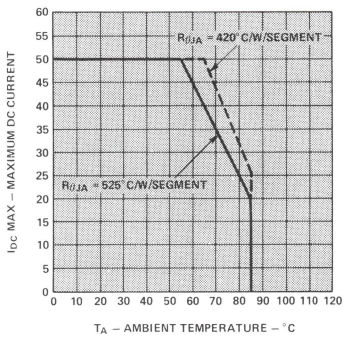


Figure 2. Maximum Allowable DC Current per Segment vs. Ambient Temperature

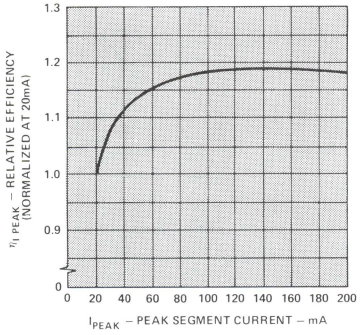


Figure 3. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

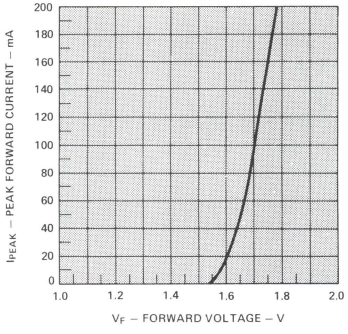


Figure 4. Peak Forward Segment Current vs. Peak Forward Voltage

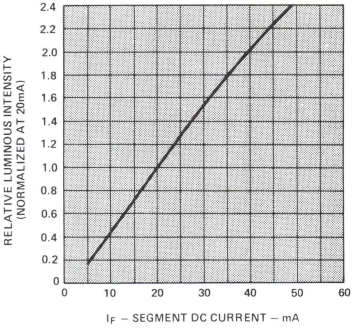


Figure 5. Relative Luminous Intensity vs. DC Forward Current

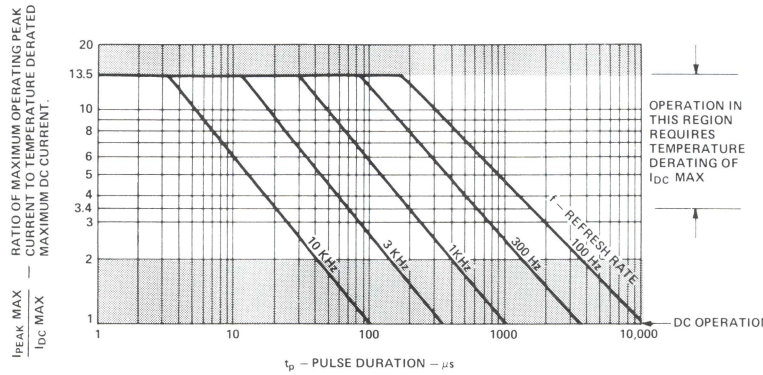


Figure 6. Maximum Allowed Peak Current vs. Pulse Duration

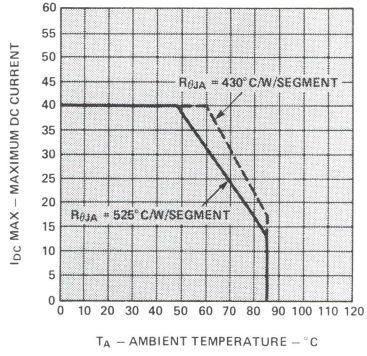


Figure 7. Maximum Allowable DC Current per Segment vs. Ambient Temperature

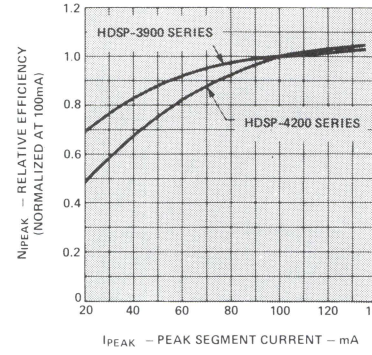


Figure 8. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

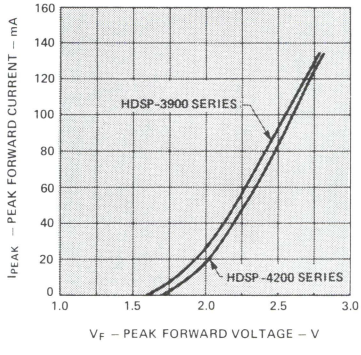


Figure 9. Peak Forward Segment Current vs. Peak Forward Voltage

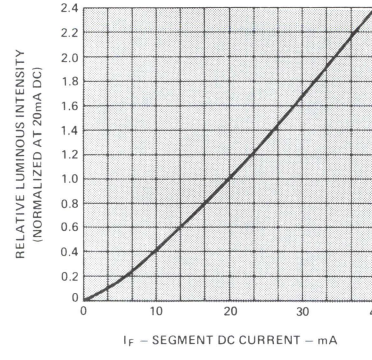


Figure 10. Relative Luminous Intensity vs. DC Forward Current

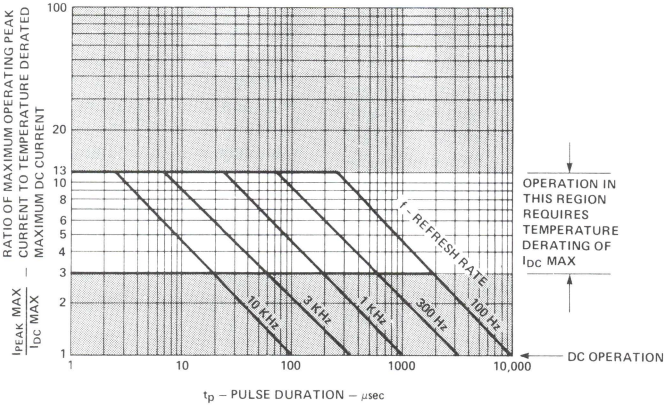


Figure 11. Maximum Allowed Peak Current vs. Pulse Duration

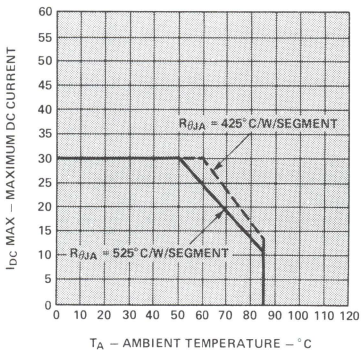


Figure 12. Maximum Allowable DC Current per Segment vs. Ambient Temperature

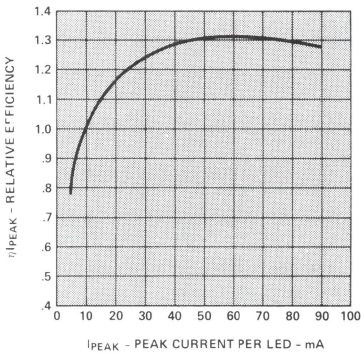


Figure 13. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

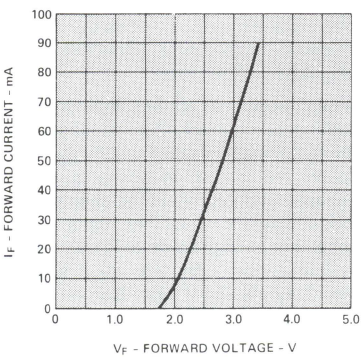


Figure 14. Peak Forward Segment Current vs. Peak Forward Voltage

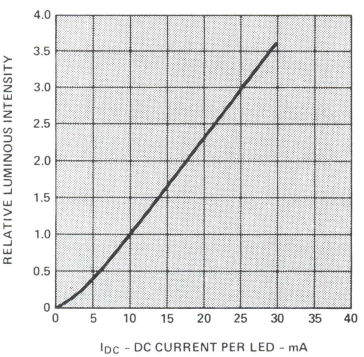


Figure 15. Relative Luminous Intensity vs. DC Forward Current

Electrical

These display devices are composed of eight light emitting diodes, with light from each LED optically stretched to form individual segments and a decimal point.

These display devices are designed for strobed operation. The typical forward voltage values, scaled from Figure 4, 9, or 14 should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F MAX models:

HDSP-3400 Series	V_F MAX = 1.55 V + I_{PEAK} (7Ω) For: $I_{PEAK} \geq 5$ mA
HDSP-3900/-4200 Series	V_F MAX = 2.15 V + I_{PEAK} (13.5Ω) For: $I_F \geq 30$ mA
	V_F MAX = 1.9 V + I_{DC} (21.8Ω) For: 10 mA ≤ I_F ≤ 30 mA
HDSP-8600 Series	V_F MAX = 2.0 V + I_{PEAK} (50Ω) For: $I_{PEAK} \geq 5$ mA

Temperature derated strobed operating conditions are obtained from Figures 1, 6, or 11 and 2, 7, or 12. Figures 1, 6, and 11 relate pulse duration (t_p), refresh rate (f), and the ratio of maximum peak current to maximum dc current (I_{PEAK} MAX/I_{DC} MAX). Figures 2, 7, and 12 present the maximum allowed dc current vs. ambient temperature. Figures 1, 6, and 11 are based on the principle that the peak junction temperature for pulsed operation at a specified peak current, pulse duration and refresh rate should be the same as the junction temperature at maximum DC operation. Refresh rates of 1 kHz or faster minimize the pulsed junction heating effect of the device resulting in the maximum possible time average luminous intensity.

The time average luminous intensity can be calculated knowing the average forward current and relative efficiency characteristic, η_{IPEAK}, of Figures 3, 8, or 13. Time average luminous intensity for a device case temperature of 25° C, I_V (25° C), is calculated as follows:

$$I_V\ (25^\circ C) = \left[\frac{I_{AVG}}{I_{AVG}\ \text{Test Condition}}\right]\left[\eta_{IPEAK}\right]\left[I_V\ \text{DATA SHEET}\right]$$

Example: For HDSP-4200 series

η_{IPEAK} = 1.00 at I_{PEAK} = 100 mA. For DF = 1/5:

$$I_V\ (25^\circ C) = \left[\frac{20\ mA}{20\ mA}\right]\left[1.00\right]\left[7.0\ mcd\right] = 7.0\ mcd/\text{segment}$$

The time average luminous intensity may be adjusted for operating junction temperature by the following exponential equation:

$$I_V\ (T_J) = I_V\ (25^\circ C)\ e^{\left[k(T_J + 25^\circ C)\right]}$$

where $T_J = T_A + P_D \cdot R\theta_{J-A}$

Device	K
-3400	-0.0188/° C
-3900	-0.0131/° C
-4200	-0.0112/° C
-8600	-0.0044/° C

Mechanical

These devices are constructed utilizing a lead frame in a standard DIP package. The LED dice are attached directly to the lead frame. Therefore, the cathode leads are the direct thermal and mechanical stress paths to the LED dice. The absolute maximum allowed junction temperature, T_J MAX, is 105° C. The maximum power ratings have been established so that the worst case V_F device does not exceed this limit.

Worst case thermal resistance pin-to-ambient is 400° C/W/Seg when these devices are soldered into minimum trace width PC boards. When installed in a PC board that provides $R\theta_{PIN-A}$ less than 400° C/W/Seg these displays may be operated at higher average currents as shown in Figure 2.

Optical

The radiation pattern for these devices is approximately Lambertian. The luminous sterance may be calculated using one of the two following formulas.

$$L_V\ (cd/m^2) = \frac{I_V\ (cd)}{A\ (m^2)}$$

$$L_V\ (\text{footlamberts}) = \frac{\pi I_V\ (cd)}{A\ (ft^2)}$$

Area/Seg. mm^2	Area/Seg. $in.^2$
14.9	0.0231

Contrast Enhancement

The objective of contrast enhancement is to optimize display readability. Adequate contrast enhancement can be achieved in indoor applications through luminous contrast techniques. Luminous contrast is the observed brightness of the illuminated segment compared to the brightness of the surround. Appropriate wavelength filters maximize luminous contrast by reducing the amount of light reflected from the area around the display while transmitting most of the light emitted by the segment. These filters are described further in Application Note 1015.

Chrominance contrast can further improve display readability. Chrominance contrast refers to the color difference between the illuminated segment and the surrounding area. These displays are assembled with a gray package and untinted encapsulating epoxy in the segments to improve chrominance contrast of the ON segments. Additional contrast enhancement in bright ambients may be achieved by using a neutral density gray filter such as Panelgraphic Chromafilter Gray 10, or 3M Light Control Film (louvered film).

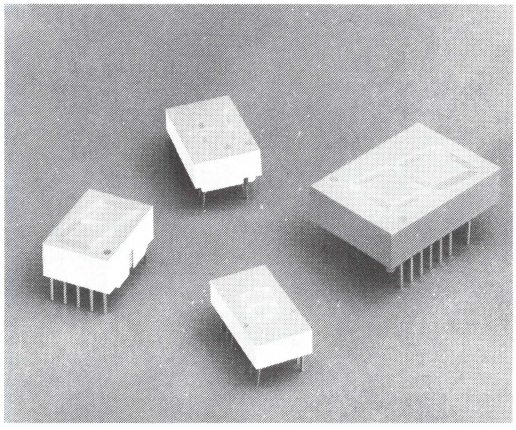
HEWLETT PACKARD

SEVEN SEGMENT DISPLAYS FOR HIGH LIGHT AMBIENT CONDITIONS

HIGH EFFICIENCY RED HDSP-3530/-3730/-5531/-3900 SERIES YELLOW HDSP-4030/-4130/-5731/-4200 SERIES

Features

- **HIGH LIGHT OUTPUT**
  Typical Intensities of up to 7.0 mcd/seg at 100 mA pk 1 of 5 duty factor.
- **CAPABLE OF HIGH CURRENT DRIVE**
  Excellent for Long Digit String Multiplexing
- **FOUR CHARACTER SIZES**
  7.6 mm, 10.9 mm, 14.2 mm, and 20.3 mm
- **CHOICE OF TWO COLORS**
  High Efficiency Red
  Yellow
- **EXCELLENT CHARACTER APPEARANCE**
  Evenly Lighted Segments
  Wide Viewing Angle
  Grey Body for Optimum Contrast
- **CATEGORIZED FOR LUMINOUS INTENSITY; YELLOW CATEGORIZED FOR COLOR**
  Use of Like Categories Yields a Uniform Display
- **IC COMPATIBLE**
- **MECHANICALLY RUGGED**



Description

The HDSP-3530/-3730/-5531/-3900 and HDSP-4030/-4130/-5731/-4200 are 7.6 mm, 10.9 mm/14.2 mm/20.3 mm high efficiency red and yellow displays designed for use in high light ambient condition. The four sizes of displays allow for viewing distances at 3, 6, 7, and 10 meters. These seven segment displays utilize large junction high efficiency LED chips made from GaAsP on a transparent GaP substrate. Due to the large junction area, these displays can be driven at high peak current levels needed for high ambient conditions or many character multiplexed operation.

These displays have industry standard packages, and pin configurations and ±1 overflow display are available in all four sizes. These numeric displays are ideal for applications such as Automotive and Avionic Instrumentation, Point of Sale Terminals, and Gas Pump.

Devices

Part No. HDSP-	Color	Description	Package Drawing
3530	High Efficiency Red	7.6 mm Common Anode Left Hand Decimal	A
3531		7.6 mm Common Anode Right Hand Decimal	B
3533		7.6 mm Common Cathode Right Hand Decimal	C
3536		7.6 mm Universal Overflow ±1 Right Hand Decimal	D
4030	Yellow	7.6 mm Common Anode Left Hand Decimal	A
4031		7.6 mm Common Anode Right Hand Decimal	B
4033		7.6 mm Common Cathode Right Hand Decimal	C
4036		7.6 mm Universal Overflow ±1 Right Hand Decimal	D

Note: Universal pinout brings the anode and cathode of each segment's LED out to separate pins. See internal diagrams D and H.

Devices

Part No. HDSP	Color	Description	Package Drawing
3730	High Efficiency Red	10.9 mm Common Anode Left Hand Decimal	E
3731		10.9 mm Common Anode Right Hand Decimal	F
3733		10.9 mm Common Cathode Right Hand Decimal	G
3736		10.9 mm Universal Overflow ±1 Right Hand Dec.	H
4130	Yellow	10.9 mm Common Anode Left Hand Decimal	E
4131		10.9 mm Common Anode Right Hand Decimal	F
4133		10.9 mm Common Cathode Right Hand Decimal	G
4136		10.9 mm Universal Overflow ±1 Right Hand Dec.	H
5531	High Efficiency Red	14.2 mm Common Anode Right Hand Decimal	I
5533		14.2 mm Common Cathode Right Hand Decimal	J
5537		14.2 mm Overflow ±1 Common Anode	K
5538		14.2 mm Overflow ±1 Common Cathode	L
5731	Yellow	14.2 mm Common Anode Right Hand Decimal	I
5733		14.2 mm Common Cathode Right Hand Decimal	J
5737		14.2 mm Overflow ±1 Common Anode	K
5738		14.2 mm Overflow ±1 Common Cathode	L
3900	High Efficiency Red	20.3 mm Common Anode Left Hand Decimal	M
3901		20.3 mm Common Anode Right Hand Decimal	N
3903		20.3 mm Common Cathode Right Hand Decimal	O
3905		20.3 mm Common Cathode Left Hand Decimal	P
3906		20.3 mm Universal Overflow ±1 Right Hand Decimal	Q
4200	Yellow	20.3 mm Common Anode Left Hand Decimal	M
4201		20.3 mm Common Anode Right Hand Decimal	N
4203		20.3 mm Common Cathode Right Hand Decimal	O
4205		20.3 mm Common Cathode Left Hand Decimal	P
4206		20.3 mm Universal Overflow ±1 Right Hand Decimal	Q

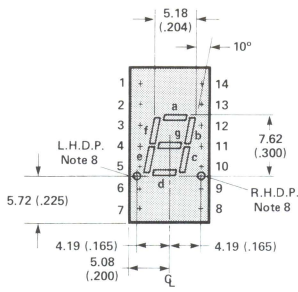
Note: Universal pinout brings the anode and cathode of each segment's LED out to separate pins. See internal diagram Q.

Absolute Maximum Ratings (All Products)

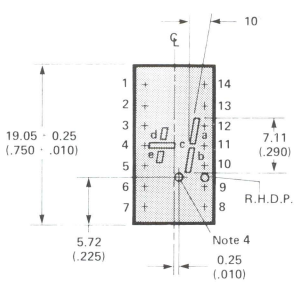
Average Power per Segment or DP ($T_A = 25°C$)	105 mW
Peak Forward Current per Segment or DP ($T_A = 25°C$)[1]	135 mA (Pulse Width = 0.16 ms)
DC Forward Current per Segment[2] or DP ($T_A = 25°C$)	40 mA
Operating Temperature Range	-40°C to +85°C
Storage Temperature Range	-55°C to +100°C
Reverse Voltage per Segment or DP	3.0V
Lead Solder Temperature (1.59 mm [1/16 inch] below seating plane)	260°C for 3 sec.

Notes:
1. See Figure 1 to establish pulsed operating conditions.
2. Derate maximum DC current above $T_A = 25°C$ at .50 mA/°C per segment, see Figure 2.

Package Dimensions (HDSP-3530/4030 Series)

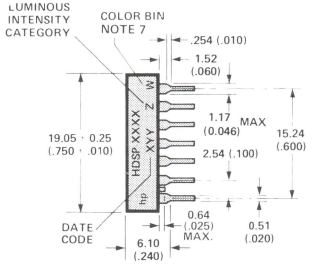


A,B,C

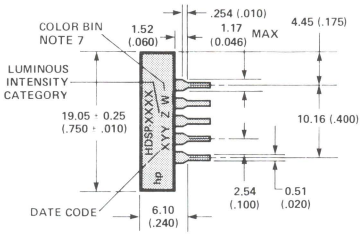


D

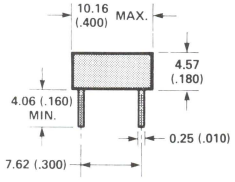
PIN	FUNCTION			
	A -3530/-4030	B -3531/-4031	C -3533/-4033	D -3536/-4036
1	CATHODE-a	CATHODE-a	NO PIN	ANODE-d
2	CATHODE-f	CATHODE-f	CATHODE [6]	NO PIN
3	ANODE[3]	ANODE[3]	ANODE-f	CATHODE-d
4	NO PIN	NO PIN	ANODE-g	CATHODE-c
5	NO PIN	NO PIN	ANODE-e	CATHODE-e
6	CATHODE-dp	NO CONN.[5]	ANODE-d	ANODE-e
7	CATHODE-e	CATHODE-e	NO PIN	ANODE-c
8	CATHODE-d	CATHODE-d	NO PIN	ANODE-dp
9	NO CONN.[5]	CATHODE-dp	CATHODE [6]	NO PIN
10	CATHODE-c	CATHODE-c	ANODE-dp	CATHODE-dp
11	CATHODE-g	CATHODE-g	ANODE-c	CATHODE-b
12	NO PIN	NO PIN	ANODE-b	CATHODE-a
13	CATHODE-b	CATHODE-b	ANODE-a	ANODE-a
14	ANODE[3]	ANODE[3]	NO PIN	ANODE-b



A,B,D
SIDE

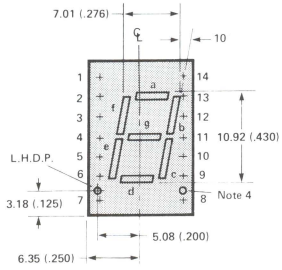


C
SIDE

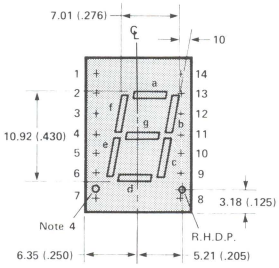


A,B,C,D
END

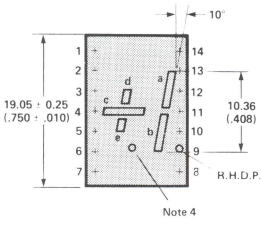
Package Dimensions (HDSP-3730/4130 Series)



E



F,G
FRONT VIEW



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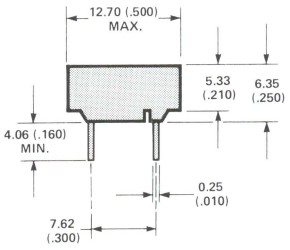
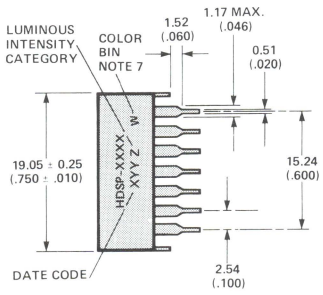


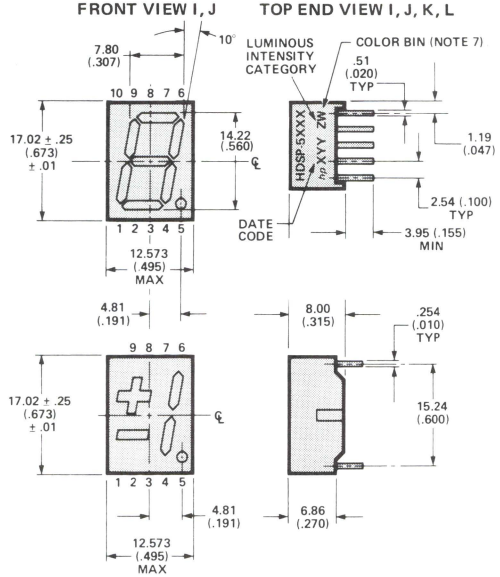
END VIEW



SIDE VIEW

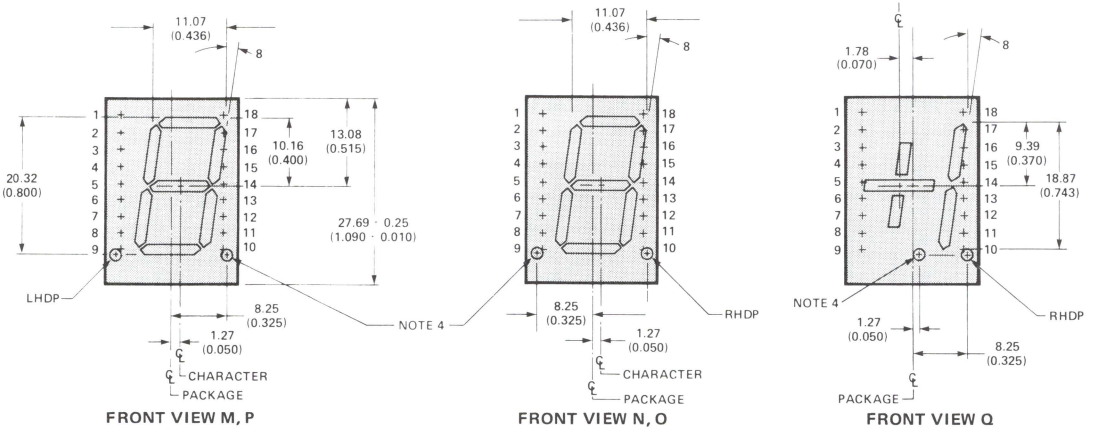
PIN	FUNCTION			
	E -3730/-4130	F -3731/-4131	G -3733/-4133	H -3736/-4136
1	CATHODE-a	CATHODE-a	ANODE-a	CATHODE-d
2	CATHODE-f	CATHODE-f	ANODE-f	ANODE-d
3	ANODE[3]	ANODE[3]	CATHODE[6]	NO PIN
4	NO PIN	NO PIN	NO PIN	CATHODE-c
5	NO PIN	NO PIN	NO PIN	CATHODE-e
6	CATHODE-dp	NO CONN.[5]	NO CONN.[5]	ANODE-e
7	CATHODE-e	CATHODE-e	ANODE-e	ANODE-c
8	CATHODE-d	CATHODE-d	ANODE-d	ANODE-dp
9	NO CONN.[5]	CATHODE-dp	ANODE-dp	CATHODE-dp
10	CATHODE-c	CATHODE-c	ANODE-c	CATHODE-b
11	CATHODE-g	CATHODE-g	ANODE-g	CATHODE-a
12	NO PIN	NO PIN	NO PIN	NO PIN
13	CATHODE-b	CATHODE-b	ANODE-b	ANODE-a
14	ANODE[3]	ANODE[3]	CATHODE[6]	ANODE-b

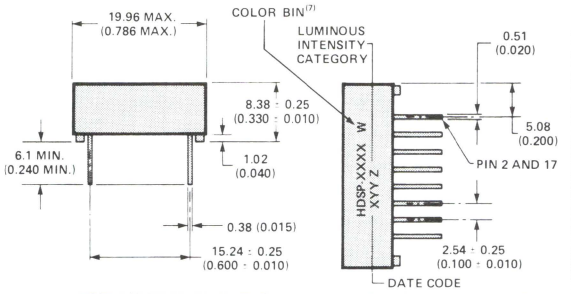
Package Dimensions (5531/5731 Series)



PIN	FUNCTION			
	I 5531	J 5533	K 5537	L 5538
1	CATHODE e	ANODE e	CATHODE c	ANODE c
2	CATHODE d	ANODE d	ANODE c, d	CATHODE c, d
3	ANODE[3]	CATHODE[6]	CATHODE b	ANODE b
4	CATHODE c	ANODE c	ANODE a, b DP	CATHODE a, b, DP
5	CATHODE DP	ANODE DP	CATHODE DP	ANODE DP
6	CATHODE b	ANODE b	CATHODE a	ANODE a
7	CATHODE a	ANODE a	ANODE a, b, DP	CATHODE a, b, DP
8	ANODE[3]	CATHODE[6]	ANODE c, d	CATHODE c, d
9	CATHODE f	ANODE f	CATHODE d	ANODE d
10	CATHODE g	ANODE g	NO PIN[5]	NO PIN[5]

Package Dimensions (3900/4200 Series)



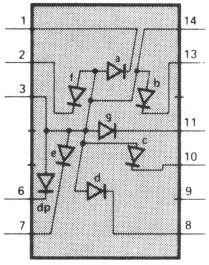


Pin	Function				
	M 3900/4200	N 3901/4201	O 3903/4203	P 3905/4205	Q 3906/4206
1	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
2	CATHODE a	CATHODE a	ANODE a	ANODE a	CATHODE a
3	CATHODE f	CATHODE f	ANODE f	ANODE f	ANODE d
4	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE d
5	CATHODE e	CATHODE e	ANODE e	ANODE e	CATHODE c
6	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE e
7	CATHODE dp	NO. CONNEC	NO. CONNEC	ANODE dp	ANODE e
8	NO PIN	NO PIN	NO PIN	NO PIN	CATHODE dp
9	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
10	NO PIN	CATHODE dp	ANODE dp	NO PIN	ANODE dp
11	CATHODE d	CATHODE d	ANODE d	ANODE d	CATHODE dp
12	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE b
13	CATHODE c	CATHODE c	ANODE c	ANODE c	ANODE b
14	CATHODE g	CATHODE g	ANODE g	ANODE g	ANODE c
15	CATHODE b	CATHODE b	ANODE b	ANODE b	ANODE a
16	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN
17	ANODE[3]	ANODE[3]	CATHODE[6]	CATHODE[6]	CATHODE a
18	NO PIN	NO PIN	NO PIN	NO PIN	NO PIN

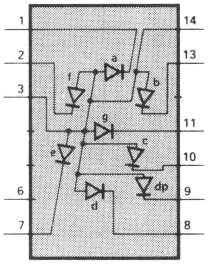
NOTES:

1. Dimensions in millimeters and (inches).
2. All untoleranced dimensions are for reference only.
3. Redundant anodes.
4. Unused dp position.
5. See Internal Circuit Diagram.
6. Redundant Cathodes.
7. For HDSP-4030/-4130/-5731/-4200 Series product only.
8. See part number table for LHDP and RHDP designation.

Internal Circuit Diagram (HDSP-3530/4030 Series)



A



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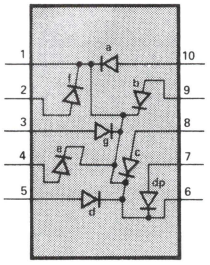

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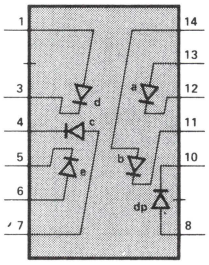
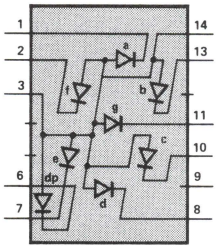
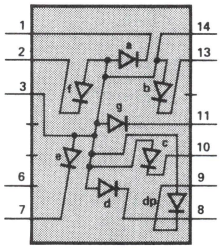


D

Internal Circuit Diagram (HDSP-3730/4130 Series)



E



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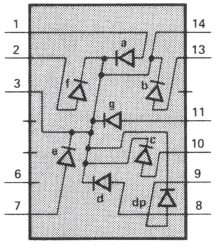

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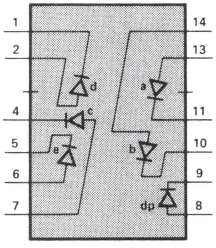
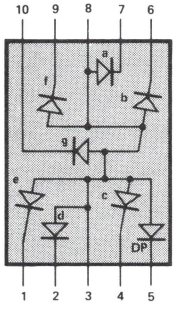


H

Internal Circuit Diagram (HDSP-5531/5731 Series)



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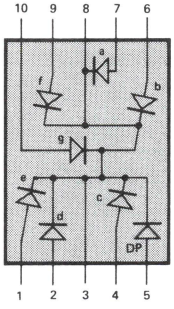

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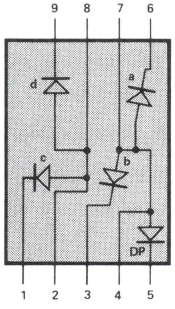

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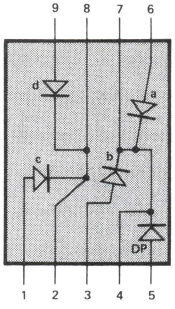
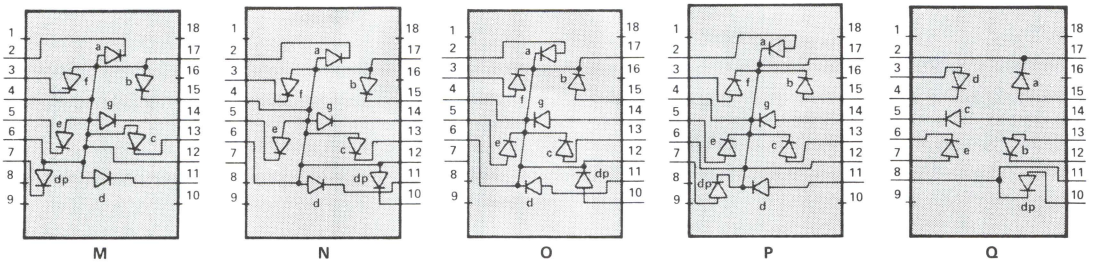


L

Internal Circuit Diagram (HDSP-3900/4200 Series)



Electrical/Optical Characteristics at T_A = 25°C

Parameter	Symbol	Device HDSP-	Test Condition	Min	Typ	Max	Units
Luminous Intensity/ Segment[9,10] (Digit Average)	I_V	3530 3730 5531 3900	100 mA Pk; 1 of 5 Duty Factor	2200 3350 2200 2200	7100 10860 6000 7000		µcd
		3530 3730 5531 3900	20 mA DC		4970 7600 5000 4800		µcd
		4030 4130 5731 4200	100 mA Pk; 1 of 5 Duty Factor	1500 1500 2200 2200	4500 5000 5500 7000		µcd
		4030 4130 5731 4200	20 mA DC		2200 2500 2800 3400		µcd
Peak Wavelength	λ_{PEAK}	3530/3730/ 5531/3900			635		nm
		4030/4130/ 5731/4200			583		nm
Dominant Wavelength[11, 12] (Digit Average)	λ_d	3530/3730/ 5531/3900			626		
		4030/4130/ 5731/4200		581.5	586	592.5	nm
Forward Voltage/Segment or D.P.[13]	V_F	All Devices	I_F = 100 mA		2.6	3.5	V
Reverse Voltage/Segment or D.P.[13, 14]	V_R	All Devices	I_R = 100 µA	3.0	25.0		V
Temp. Coeff. of V_F/Seg or D.P.	ΔV_F/° C	All Devices	I_F = 100 mA		-1.1		mV/° C
Thermal Resistance LED Junction-to-pin	$R\theta_{J-PIN}$	3530/4030/ 3730/4130			282		° C/W/Seg
		5531/5731			345		° C/W/Seg
		3900/4200			375		° C/W/Seg

Notes:

9. Case temperature of the device immediately prior to the intensity measurement is 25° C.
10. The digits are categorized for luminous intensity with the intensity category designated by a letter on the side of the package.
11. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and is that single wavelength which defines the color of the device.
12. The yellow displays are categorized as to dominant wavelength with the category designated by a number adjacent to the intensity category letter.
13. Quality level for electrical characteristics is 1000 parts per million.
14. Typical specification for reference only. Do not exceed absolute maximum ratings.

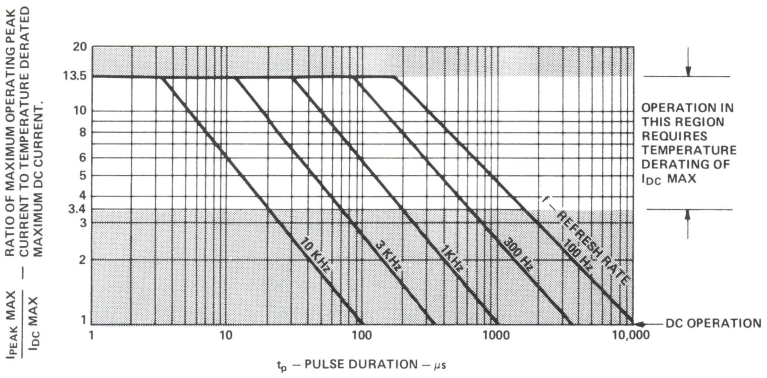


Figure 1. Maximum Allowed Peak Current vs. Pulse Duration

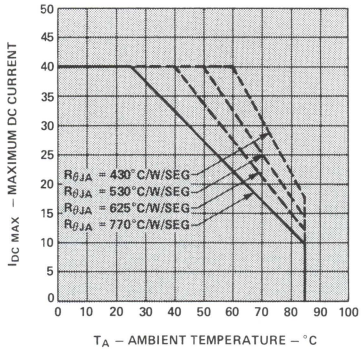


Figure 2. Maximum Allowable DC Current per Segment vs. Ambient Temperature

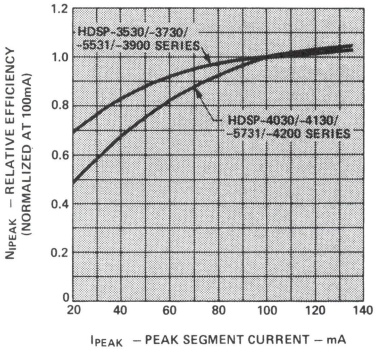


Figure 3. Relative Efficiency (Luminous Intensity per Unit Current) vs. Peak Segment Current

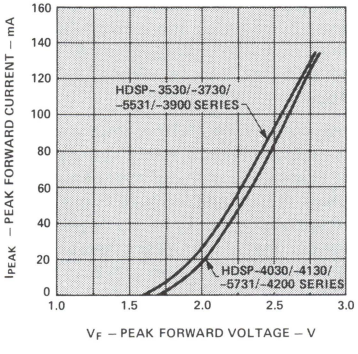


Figure 4. Peak Forward Segment Current vs. Peak Forward Voltage

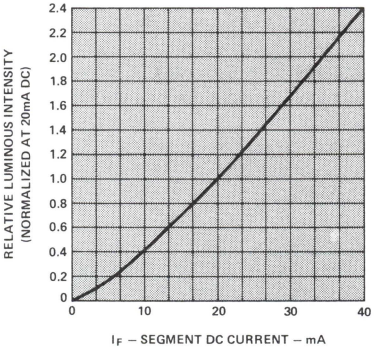


Figure 5. Relative Luminous Intensity vs. DC Forward Current

Electrical

These display devices are composed of eight light emitting diodes, with light from each LED optically stretched to form individual segments and a decimal point.

The devices utilize LED chips which are made from GaAsP on a transparent GaP substrate.

These display devices are designed for strobed operation. The typical forward voltage values, scaled from Figure 4 should be used for calculating the current limiting resistor value and typical power dissipation. Expected maximum V_F values, for the purpose of driver circuit design and maximum power dissipation, may be calculated using the following V_F MAX models:

V_F MAX = 2.15V + I_{PEAK} (13.5Ω)
For: $I_F \geq 30$ mA

V_F MAX = 1.9V + I_{DC} (21.8Ω)
For: 10 mA ≤ $I_F \leq$ 30 mA

Temperature derated strobed operating conditions are obtained from Figures 1 and 2. Figure 1 relates pulse duration (t_p), refresh rate (f), and the ratio of maximum peak current to maximum dc current (I_{PEAK} MAX/I_{DC} MAX). Figure 2 presents the maximum allowed dc current vs. ambient temperature. Figure 1 is based on the principle that the peak junction temperature for pulsed operation at a specified peak current, pulse duration and refresh rate should be the same as the junction temperature at maximum DC operation. Refresh rates of 1 kHz or faster minimize the pulsed junction heating effect of the device resulting in the maximum possible time average luminous intensity.

The time average luminous intensity can be calculated knowing the average forward current and relative efficiency characteristic, ηI_{PEAK}, of Figure 3. Time average luminous intensity for a device case temperature of 25° C, I_V (25° C), is calculated as follows:

$$I_V\,(25^\circ C) = \left[\frac{I_{AVG}}{20\text{ mA}}\right]\left[\eta_{IPEAK}\right]\left[I_V \text{ DATA SHEET}\right]$$

Example: For HDSP-4030 series

η_{IPEAK} = 1.00 at I_{PEAK} = 100 mA. For DF = 1/5:

$$I_V\,(25^\circ C) = \left[\frac{20\text{ mA}}{20\text{ mA}}\right]\left[1.00\right]\left[4.5\text{ mcd}\right] = 4.5\text{ mcd/segment}$$

The time average luminous intensity may be adjusted for operating junction temperature by the following exponential equation:

$$I_V\,(T_J) = I_V\,(25^\circ C)\, e^{[k(T_J + 25^\circ C)]}$$

where $T_J = T_A + P_D \cdot R\theta_{J-A}$

DEVICE	K
-3530/-3730/-5531/-3900	-0.0131/° C
-4030/-4130/-5731/-4200	-0.0112/° C

Mechanical

These devices are constructed utilizing a lead frame in a standard DIP package. The LED dice are attached directly to the lead frame. Therefore, the cathode leads are the direct thermal and mechanical stress paths to the LED dice. The absolute maximum allowed junction temperature, T_J MAX, is 105° C. The maximum power ratings have been established so that the worst case V_F device does not exceed this limit.

Worst case thermal resistance pin-to-ambient is 400° C/W/Seg when these devices are soldered into minimum trace width PC boards. When installed in a PC board that provides $R\theta_{PIN-A}$ less than 400° C/W/Seg these displays may be operated at higher average currents as shown in Figure 2.

Optical

The radiation pattern for these devices is approximately Lambertian. The luminous sterance may be calculated using one of the two following formulas.

$$L_V(\text{cd/m}^2) = \frac{I_V(\text{cd})}{A(\text{m}^2)}$$

$$L_V(\text{footlamberts}) = \frac{\pi I_V(\text{cd})}{A(\text{ft}^2)}$$

DEVICE	AREA/SEG. mm^2	AREA/SEG. $IN.^2$
-3530/-4030	2.5	.0039
-3730/-4130	4.4	.0068
-5531/-5731	8.8	.0137
-3900/-4200	14.9	.0231

Contrast Enhancement

The objective of contrast enhancement is to optimize display readability. Adequate contrast enhancement can be achieved in indoor applications through luminous contrast techniques. Luminous contrast is the observed brightness of the illuminated segment compared to the brightness of the surround. Appropriate wavelength filters maximize luminous contrast by reducing the amount of light reflected from the area around the display while transmitting most of the light emitted by the segment. These filters are described further in Application Note 1015.

Chrominance contrast can further improve display readability. Chrominance contrast refers to the color difference between the illuminated segment and the surrounding area. These displays are assembled with a gray package and untinted encapsulating epoxy in the segments to improve chrominance contrast of the ON segments. Additional contrast enhancement in bright ambients may be achieved by using a neutral density gray filter such as Panelgraphic Chromafilter Gray 10, or 3M Light Control Film (louvered film).

HEWLETT PACKARD

INTENSITY AND COLOR SELECTED DISPLAYS

Features

- **INTENSITY SELECTION IMPROVES UNIFORMITY OF LIGHT OUTPUT FROM UNIT TO UNIT. AVAILABLE IN RED, HIGH EFFICIENCY RED, AND HIGH PERFORMANCE GREEN.**
- **COLOR SELECTION IMPROVES UNIFORMITY OF COLOR FROM UNIT TO UNIT. AVAILABLE IN YELLOW.**
- **ONE AND TWO CATEGORY SELECTION SIMPLIFIES INVENTORY CONTROL AND ASSEMBLY.**

Description

Seven segment displays are now available from Hewlett-Packard which are selected from one category or from two categories. These select displays are basic catalog devices which are pre-sorted for luminous intensity and color, then selected from one predetermined category (S01 Option) or two predetermined adjacent categories (S02 Option). Each option will be assigned to a part number.

Example: One luminous intensity category is selected from the basic catalog 5082-7750 production distribution and assigned to the part number 5082-7750 Option S01. Two luminous intensity categories are assigned the part number 5082-7750 Option S02.

Luminous intensity selection is available for red and high efficiency red for S01 Option and for red, high efficiency red, and high performance green for S02 Option. Color selection is available for yellow on selected products.

To ensure our customers a steady supply of product, HP must offer selected units from the center of our distribution. If our production distribution shifts, we will need to change the intensity or color range of the selected units our customers receive. Typically, an intensity may have to be changed once every 1 to 3 years.

Current intensity and color selection information is available through a category reference chart which is available through your local field sales engineer or local franchised distributor.

Absolute Maximum Ratings and Electrical/Optical Characteristics

The absolute maximum ratings, mechanical dimensions, and electrical/optical characteristics are identical to the basic catalog device.

Device Selection Guide

The following table summarizes which basic catalog devices are available with category selection.

	COLOR					
Character Height	**Red**	**High Efficiency Red**	**High Ambient High Efficiency Red**	**Yellow**	**High Ambient High Efficiency Yellow**	**High Performance Green**
7.62 mm (0.3") Microbright	HDSP-7301 S01 & S02 Option HDSP-7303 S01 & S02 Option HDSP-7307 S01 & S02 Option HDSP-7308 S01 & S02 Option	HDSP-7501 S01 & S02 Option HDSP-7503 S01 & S02 Option HDSP-7507 S01 & S02 Option HDSP-7508 S01 & S02 Option	Basic Family Not Applicable	Selected Version Not Available	Basic Family Not Applicable	HDSP-7801 Option S02 HDSP-7803 Option S02 HDSP-7807 Option S02 HDSP-7808 Option S02
7.62 mm (0.3")	5082-7730 S01 & S02 Option 5082-7731 S01 & S02 Option 5082-7736 S01 & S02 Option 5082-7740 S01 & S02 Option	5082-7610 S01 & S02 Option 5082-7611 S01 & S02 Option 5082-7613 S01 & S02 Option 5082-7616 S01 & S02 Option	HDSP-3530 Option S02 HDSP-3531 Option S02 HDSP-3533 Option S02 HDSP-3536 Option S02	Selected Version Not Available	Selected Version Not Available	HDSP-3600 Option S02 HDSP-3603 Option S02 HDSP-3606 Option S02
10.92 mm (0.43")	5082-7750 S01 & S02 Option 5082-7751 S01 & S02 Option 5082-7756 S01 & S02 Option 5082-7760 S01 & S02 Option	5082-7650 S01 & S02 Option 5082-7651 S01 & S02 Option 5082-7653 S01 & S02 Option 5082-7656 S01 & S02 Option	HDSP-3730 Option S02 HDSP-3731 Option S02 HDSP-3733 Option S02 HDSP-3736 Option S02	5082-7663 Option S20 5082-7666 Option S20	HDSP-4133 Option S20 HDSP-4136 Option S20	Selected Version Not Available
14.2 mm (0.56") Single Digit	HDSP-5301 S01 & S02 Option HDSP-5303 S01 & S02 Option HDSP-5307 S01 & S02 Option HDSP-5308 S01 & S02 Option	HDSP-5501 S01 & S02 Option HDSP-5503 S01 & S02 Option HDSP-5507 S01 & S02 Option HDSP-5508 S01 & S02 Option	HDSP-5531 Option S02 HDSP-5533 Option S02 HDSP-5537 Option S02 HDSP-5538 Option S02	Selected Version Not Available	Selected Version Not Available	HDSP-5601 Option S02 HDSP-5607 Option S02
14.2 mm (0.56") Dual Digit	HDSP-5321 S02 Option HDSP-5323 S02 Option	HDSP-5521 S01 & S02 Option HDSP-5523 S01 & S02 Option	Basic Family Not Applicable	Selected Version Not Available	Basic Family Not Applicable	Selected Version Not Available
20 mm (0.8")	HDSP-3400 S02 Option HDSP-3403 S02 Option HDSP-3406 S02 Option	Basic Family Not Applicable	HDSP-3900 Option S02 HDSP-3901 Option S02 HDSP-3903 Option S02 HDSP-3906 Option S02	Basic Family Not Applicable	Selected Version Not Available	Selected Version Not Available

Notes:

1. Option S01 designates a one intensity category selection.
2. Option S02 designates two intensity category selection.
3. Option S20 designates a two color category selection.
4. Option S01 and S02 of different part numbers may not have the same apparent brightness. Contact your HP Field Sales Office for design assistance.

HEWLETT PACKARD

HEXADECIMAL AND NUMERIC DISPLAYS

5082-7300
5082-7302
5082-7304
5082-7340

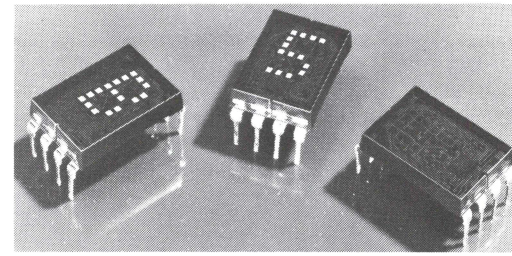
Features

- NUMERIC
  5082-7300/-7302
  0-9, Test State, Minus Sign, Blank States, Decimal Point
  7300 Right Hand D. P.
  7302 Left Hand D.P.
- HEXADECIMAL
  5082-7340
  0-9, A-F, Base 16 Operation, Blanking Control, Conserves Power, No Decimal Point
- TTL COMPATIBLE
- INCLUDES DECODER/DRIVER WITH MEMORY
  8421 Positive Logic Input
- 4 x 7 DOT MATRIX ARRAY
  Shaped Character, Excellent Readability
- STANDARD DUAL-IN-LINE PACKAGE INCLUDING CONTRAST FILTER
  15.2 mm x 10.2 mm (0.6 inch x 0.4 inch)
- CATEGORIZED FOR LUMINOUS INTENSITY

Description

The HP 5082-7300 series solid state numeric and hexadecimal displays with on-board decoder/driver and memory provide 7.4 mm (0.29 inch) displays for reliable, low-cost methods of displaying digital information.

The 5082-7300 numeric display decodes positive 8421 BCD logic inputs into characters 0-9, a "—" sign, a test pattern, and four blanks in the invalid BCD states. The unit employs a right-hand decimal point.



The 5082-7302 is the same as the 5082-7300, except that the decimal point is located on the left-hand side of the digit.

The 5082-7340 hexadecimal display decodes positive 8421 logic inputs into 16 states, 0-9 and A-F. In place of the decimal point an input is provided for blanking the display (all LEDs off), without losing the contents of the memory. Applications include terminals and computer systems using the base-16 character set.

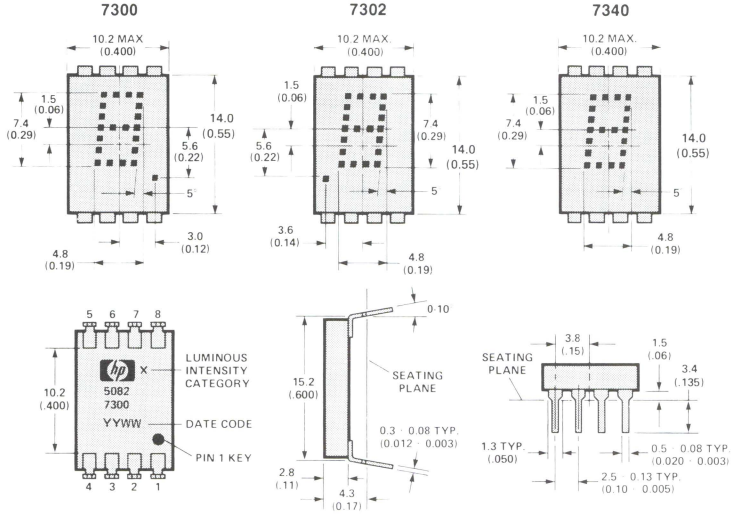
The 5082-7304 is a (±1) overrange display including a right-hand decimal point.

The ESD susceptibility of these IC devices is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263.

Applications

Typical applications include point-of-sale terminals, instrumentation, and computer system.

Package Dimensions



Pin	Function	
	5082-7300 and 7302 Numeric	5082-7340 Hexadecimal
1	Input 2	Input 2
2	Input 4	Input 4
3	Input 8	Input 8
4	Decimal Point	Blanking Control
5	Latch Enable	Latch Enable
6	Ground	Ground
7	V_{CC}	V_{CC}
8	Input 1	Input 1

Notes:
1. Dimensions in millimeters and (inches).
2. Unless otherwise specified, the tolerance on all dimensions is ±0.38 mm (± 0.015 inch).
3. Digit center line is ±0.25 mm (±0.01 inch) from package center line.

Absolute Maximum Ratings

Description	Symbol	Min.	Max.	Unit
Storage temperature, ambient	T_S	-40	+100	°C
Operating temperature, case[1,2]	T_C	-20	+85	°C
Supply voltage[3]	V_{CC}	−0.5	+7.0	V
Voltage applied to input logic, dp and enable pins	V_I, V_{DP}, V_E	−0.5	+7.0	V
Voltage applied to blanking input[7]	V_B	−0.5	V_{CC}	V
Maximum solder temperature at 1.59mm (.062 inch) below seating plane; t ⩽ 5 seconds			230	°C

Recommended Operating Conditions

Description	Symbol	Min.	Nom.	Max.	Unit
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Operating temperature, case	T_C	-20		+85	°C
Enable Pulse Width	t_W	120			nsec
Time data must be held before positive transition of enable line	t_{SETUP}	50			nsec
Time data must be held after positive transition of enable line	t_{HOLD}	50			nsec
Enable pulse rise time	t_{TLH}			200	nsec

Electrical/Optical Characteristics (T_C = -20° C to +85° C, Unless Otherwise Specified)

Description	Symbol	Test Conditions	Min.	Typ.[4]	Max.	Unit
Supply Current	I_{CC}	V_{CC} = 5.5 V (characters "5." or "B" displayed)		112	170	mA
Power dissipation	P_T			560	935	mW
Luminous intensity per LED (Digit average)[5,6]	I_v	V_{CC}=5.0V, T_C = 25° C	32	70		μcd
Logic low-level input voltage	V_{IL}	V_{CC}=4.5V			0.8	V
Logic high-level input voltage	V_{IH}		2.0			V
Enable low-voltage; data being entered	V_{EL}				0.8	V
Enable high-voltage; data not being entered	V_{EH}		2.0			V
Blanking low-voltage; display not blanked[7]	V_{BL}				0.8	V
Blanking high-voltage; display blanked[7]	V_{BH}		3.5			V
Blanking low-level input current[7]	I_{BL}	V_{CC}=5.5V, V_{BL}=0.8V			20	μA
Blanking high-level input current[7]	I_{BH}	V_{CC}=5.5V, V_{BH}=4.5V			2.0	mA
Logic low-level input current	I_{IL}	V_{CC}=5.5V, V_{IL}=0.4V			−1.6	mA
Logic high-level input current	I_{IH}	V_{CC}=5.5V, V_{IH}=2.4V			+250	μA
Enable low-level input current	I_{EL}	V_{CC}=5.5V, V_{EL}=0.4V			−1.6	mA
Enable high-level input current	I_{EH}	V_{CC}=5.5V, V_{EH}=2.4V			+250	μA
Peak wavelength	λ_{PEAK}	T_C = 25° C		655		nm
Dominant Wavelength[8]	λ_d	T_C = 25° C		640		nm
Weight				0.8		gm

Notes: 1. Nominal thermal resistance of a display mounted in a socket which is soldered into a printed circuit board: Θ_{JA} = 50° C/W; Θ_{JC} = 15° C/W; 2. Θ_{CA} of a mounted display should not exceed 35° C/W for operation up to T_C =+85° C. 3.Voltage values are with respect to device ground, pin 6. 4. All typical values at V_{CC} = 5.0 Volts, T_A = 25° C. 5. These displays are categorized for luminous intensity with the intensity category designated by a letter located on the back of the display contiguous with the Hewlett-Packard logo marking. 6. The luminous intensity at a specific case temperature, $I_V(T_C)$ may be calculated from this relationship: $I_V(T_C) = I_V$ (25° C) e [-0.0188/° C($T_{C-25°C}$)] 7. Applies only to 7340. 8. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.

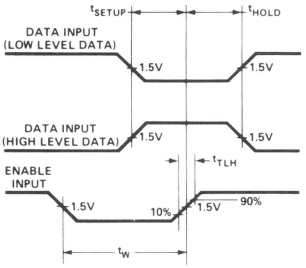


Figure 1. Timing Diagram of 5082-7300 Series Logic.

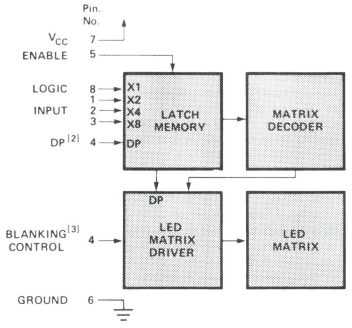


Figure 2. Block Diagram of 5082-7300 Series Logic.

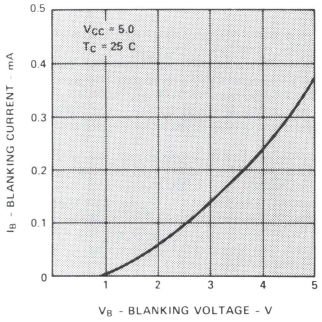


Figure 3. Typical Blanking Control Current vs. Voltage for 5082-7340.

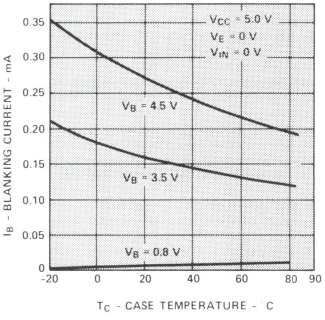


Figure 4. Typical Blanking Control Input Current vs. Temperature, 5082-7340.

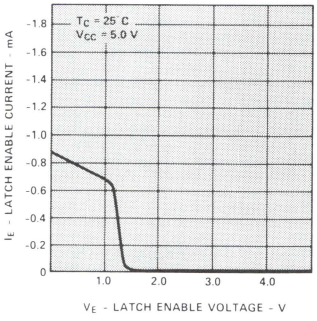


Figure 5. Typical Latch Enable Input Current vs. Voltage for the 5082-7300 Series Devices.

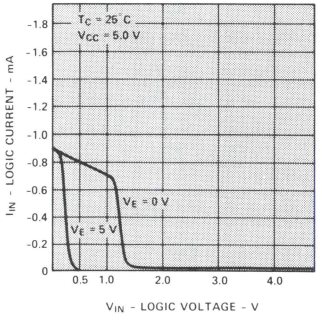


Figure 6. Typical Logic and Decimal Point Input Current vs. Voltage for the 5082-7300 Series Devices. Decimal Point Applies to 5082-7300 and -7302 Only.

TRUTH TABLE

BCD DATA [1]				5082-7300/7302	5082-7340
X_8	X_4	X_2	X_1		
L	L	L	L	0	0
L	L	L	H	1	1
L	L	H	L	2	2
L	L	H	H	3	3
L	H	L	L	4	4
L	H	L	H	5	5
L	H	H	L	6	6
L	H	H	H	7	7
H	L	L	L	8	8
H	L	L	H	9	9
H	L	H	L	0	A
H	L	H	H	(BLANK)	B
H	H	L	L	(BLANK)	C
H	H	L	H	-	D
H	H	H	L	(BLANK)	E
H	H	H	H	(BLANK)	F

DECIMAL PT [2]	ON	V_{DP} = L
	OFF	V_{DP} = H
ENABLE [1]	LOAD DATA	V_E = L
	LATCH DATA	V_E = H
BLANKING [3]	DISPLAY-ON	V_B = L
	DISPLAY-OFF	V_B = H

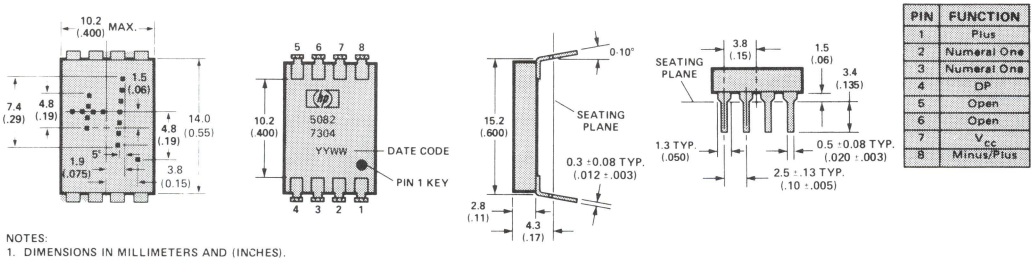
Notes:

1. H = Logic High; L = Logic Low. With the enable input at logic high changes in BCD input logic levels or D.P. input have no effect upon display memory, displayed character, or D.P.
2. The decimal point input, DP, pertains only to the 5082-7300 and 5082-7302 displays.
3. The blanking control input, B, pertains only to the 5082-7340 hexadecimal display. Blanking input has no effect upon display memory.

Solid State Over Range Display

For display applications requiring a ±, 1, or decimal point designation, the 5082-7304 over range display is available. This display module comes in the same package as the 5082-7300 series numeric display and is completely compatible with it.

Package Dimensions



PIN	FUNCTION
1	Plus
2	Numeral One
3	Numeral One
4	DP
5	Open
6	Open
7	V_{CC}
8	Minus/Plus

NOTES:
1. DIMENSIONS IN MILLIMETERS AND (INCHES).
2. UNLESS OTHERWISE SPECIFIED, THE TOLERANCE ON ALL DIMENSIONS IS ±0.38 MM (±0.015 INCHES).

5082-7304

TRUTH TABLE FOR 5082-7304

CHARACTER	PIN			
	1	2,3	4	8
+	H	X	X	H
–	L	X	X	H
1	X	H	X	X
Decimal Point	X	X	H	X
Blank	L	L	L	L

NOTES: L: Line switching transistor in Figure 7 cutoff.
H: Line switching transistor in Figure 7 saturated.
X: 'Don't care'

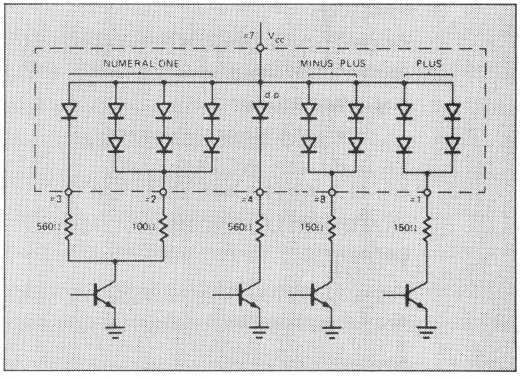


Figure 7. Typical Driving Circuit for 5082-7304

Recommended Operating Conditions

	SYMBOL	MIN	NOM	MAX	UNIT
LED supply voltage	V_{CC}	4.5	5.0	5.5	V
Forward current, each LED	I_F		5.0	10	mA

NOTE:
LED current must be externally limited. Refer to Figure 7 for recommended resistor values.

Absolute Maximum Ratings

DESCRIPTION	SYMBOL	MIN.	MAX.	UNIT
Storage temperature, ambient	T_S	–40	+100	°C
Operating temperature, case	T_C	–20	+85	°C
Forward current, each LED	I_F		10	mA
Reverse voltage, each LED	V_R		4	V

Electrical/Optical Characteristics

5082-7358 (T_C = -20° C to +85° C, Unless Otherwise Specified)

DESCRIPTION	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Forward Voltage per LED	V_F	I_F = 10 mA		1.6	2.0	V
Power dissipation	P_T	I_F = 10 mA all diodes lit		250	320	mW
Luminous Intensity per LED (digit average)	I_v	I_F = 6 mA T_C = 25°C	32	70		µcd
Peak wavelength	λ_{peak}	T_C = 25°C		655		nm
Dominant Wavelength	λd	T_C = 25°C		640		nm
Weight				0.8		gm

HEWLETT PACKARD

HEXADECIMAL AND NUMERIC DISPLAYS FOR INDUSTRIAL APPLICATIONS

5082-7356
5082-7357
5082-7358
5082-7359

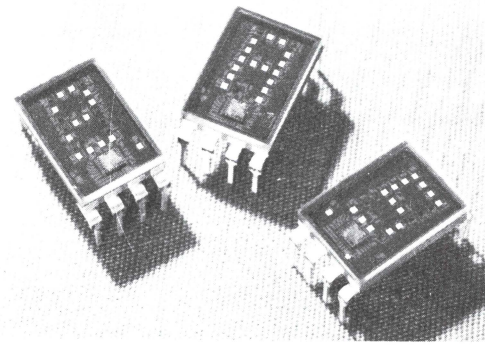
Features

- **CERAMIC/GLASS PACKAGE**
- **ADDED RELIABILITY**
- **NUMERIC 5082-7356/-7357**
  0-9, Test State, Minus Sign, Blank States, Decimal Point
  7356 Right Hand D.P., 7357 Left Hand D.P.
- **HEXADECIMAL 5082-7359**
  0-9, A-F, Base 16 Operation, Blanking Control, Conserves Power, No Decimal Point
- **TTL COMPATIBLE**
- **INCLUDES DECODER/DRIVER WITH MEMORY**
  8421 Positive Logic Input
- **4 x 7 DOT MATRIX ARRAY**
  Shaped Character, Excellent Readability
- **STANDARD DUAL-IN-LINE PACKAGE**
  15.2 mm x 10.2 mm (0.6 inch x 0.4 inch)
- **CATEGORIZED FOR LUMINOUS INTENSITY**

Description

The HP 5082-735X series solid state numeric and hexadecimal displays with on-board decoder/driver and memory provide 7.4 mm (0.29 inch) displays for use in adverse industrial environments.

The 5082-7356 numeric display decodes positive 8421 BCD logic inputs into characters 0-9 "—" sign, a test pattern, and four blanks in the invalid BCD states. The unit employs a right-hand decimal point.



The 5082-7357 is the same as the 5082-7356, except that the decimal point is located on the left-hand side of the digit.

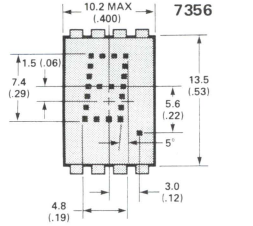
The 5082-7359 hexadecimal display decodes positive 8421 logic inputs into 16 states, 0-9 and A-F. In place of the decimal point an input is provided for blanking the display (all LED's off), without losing the contents of the memory. Applications include terminals and computer systems using the base-16 character set.

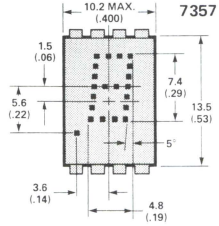
The 5082-7358 is a (±1) overrange display including a right-hand decimal point.

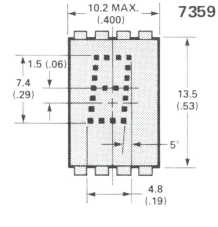
Applications

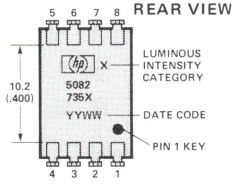
Typical applications include control systems, instrumentation, communication systems, and transportation equipment.

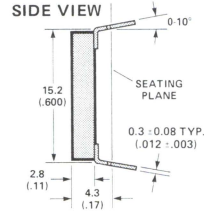
Package Dimensions

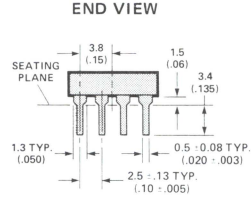












PIN	FUNCTION	
	5082-7356 AND 7357 NUMERIC	5082-7359 HEXA-DECIMAL
1	Input 2	Input 2
2	Input 4	Input 4
3	Input 8	Input 8
4	Decimal point	Blanking control
5	Latch enable	Latch enable
6	Ground	Ground
7	V_{CC}	V_{CC}
8	Input 1	Input 1

NOTES:
1. Dimensions in millimeters and (inches).
2. Unless otherwise specified, the tolerance on all dimensions is ± 0.38mm (±0.015 in.)
3. Digit center line is ± 0.25mm (±0.01 in.) from package center line.

Absolute Maximum Ratings

Description	Symbol	Min.	Max.	Unit
Storage temperature, ambient	T_S	−65	+125	°C
Operating temperature, ambient [1,2]	T_A	−55	+100	°C
Supply voltage [3]	V_{CC}	−0.5	+7.0	V
Voltage applied to input logic, dp and enable pins	V_I, V_{DP}, V_E	−0.5	+7.0	V
Voltage applied to blanking input [7]	V_B	−0.5	V_{CC}	V
Maximum solder temperature at 1.59mm (.062 inch) below seating plane; t ⩽ 5 seconds			260	°C

Recommended Operating Conditions

Description	Symbol	Min.	Nom.	Max.	Unit
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Operating temperature, ambient	T_A	-55		+85	°C
Enable Pulse Width	t_W	100			nsec
Time data must be held before positive transition of enable line	t_{SETUP}	50			nsec
Time data must be held after positive transition of enable line	t_{HOLD}	50			nsec
Enable pulse rise time	t_{TLH}			200	nsec

Electrical/Optical Characteristics (T_A = -55° C to +85° C, Unless Otherwise Specified)

Description	Symbol	Test Conditions	Min.	Typ.[4]	Max.	Unit
Supply Current	I_{CC}	V_{CC} = 5.5 V (characters "5." or "B" displayed)		112	170	mA
Power dissipation	P_T			560	935	mW
Luminous intensity per LED (Digit average) [5,6]	I_v	V_{CC}=5.0V, T_A=25° C	40	85		μcd
Logic low-level input voltage	V_{IL}	V_{CC}=4.5V			0.8	V
Logic high-level input voltage	V_{IH}		2.0			V
Enable low-voltage; data being entered	V_{EL}				0.8	V
Enable high-voltage; data not being entered	V_{EH}		2.0			V
Blanking low-voltage; display not blanked [7]	V_{BL}				0.8	V
Blanking high-voltage; display blanked [7]	V_{BH}		3.5			V
Blanking low-level input current [7]	I_{BL}	V_{CC}=5.5V, V_{BL}=0.8V			50	μA
Blanking high-level input current [7]	I_{BH}	V_{CC}=5.5V, V_{BH}=4.5V			1.0	mA
Logic low-level input current	I_{IL}	V_{CC}=5.5V, V_{IL}=0.4V			−1.6	mA
Logic high-level input current	I_{IH}	V_{CC}=5.5V, V_{IH}=2.4V			+100	μA
Enable low-level input current	I_{EL}	V_{CC}=5.5V, V_{EL}=0.4V			−1.6	mA
Enable high-level input current	I_{EH}	V_{CC}=5.5V, V_{EH}=2.4V			+130	μA
Peak wavelength	λ_{PEAK}	T_A=25° C		655		nm
Dominant Wavelength [8]	λ_d	T_A=25° C		640		nm
Weight				1.0		gm

Notes: 1. Nominal thermal resistance of a display mounted in a socket which is soldered into a printed circuit board: Θ_{JA}=50° C/W; Θ_{JC}=15° C/W; 2. Θ_{CA} of a mounted display should not exceed 35° C/W for operation up to T_A=+100° C. 3. Voltage values are with respect to device ground, pin 6. 4. All typical values at V_{CC}=5.0 Volts, T_A=25° C. 5. These displays are categorized for luminous intensity with the intensity category designated by a letter located on the back of the display contiguous with the Hewlett-Packard logo marking. 6. The luminous intensity at a specific ambient temperature, $I_V(T_A)$, may be calculated from this relationship: $I_V(T_A)=I_{V(25°C)}(.985)^{[T_A-25°C]}$ 7. Applies only to 7359. 8. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.

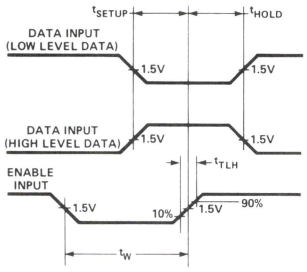


Figure 1. Timing Diagram of 5082-735X Series Logic.

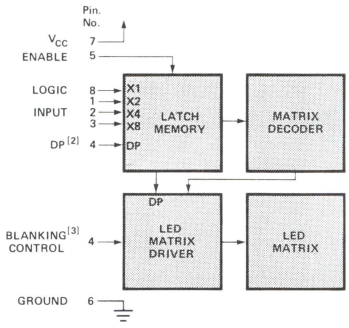


Figure 2. Block Diagram of 5082-735X Series Logic.

TRUTH TABLE					
BCD DATA [1]				5082-7356/7357	5082-7359
X_8	X_4	X_2	X_1		
L	L	L	L	0	0
L	L	L	H	1	1
L	L	H	L	2	2
L	L	H	H	3	3
L	H	L	L	4	4
L	H	L	H	5	5
L	H	H	L	6	6
L	H	H	H	7	7
H	L	L	L	8	8
H	L	L	H	9	9
H	L	H	L	-	A
H	L	H	H	(BLANK)	B
H	H	L	L	(BLANK)	C
H	H	L	H	-	D
H	H	H	L	(BLANK)	E
H	H	H	H	(BLANK)	F
DECIMAL PT. [2]		ON			V_{DP} = L
		OFF			V_{DP} = H
ENABLE [1]		LOAD DATA			V_E = L
		LATCH DATA			V_E = H
BLANKING [3]		DISPLAY-ON			V_B = L
		DISPLAY-OFF			V_B = H

Notes:
1. H = Logic High; L = Logic Low. With the enable input at logic high changes in BCD input logic levels or D.P. input have no effect upon display memory, displayed character, or D.P.
2. The decimal point input, DP, pertains only to the 5082-7356 and 5082-7357 displays.
3. The blanking control input, B, pertains only to the 5082-7359 hexadecimal display. Blanking input has no effect upon display memory.

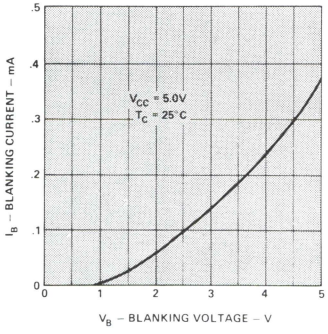


Figure 3. Typical Blanking Control Current vs. Voltage for 5082-7359.

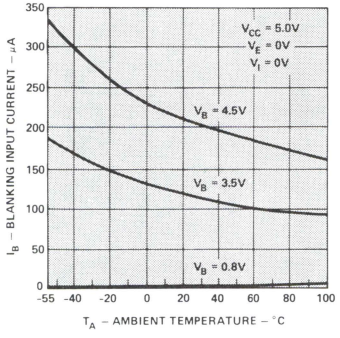


Figure 4. Typical Blanking Control Input Current vs. Ambient Temperature for 5082-7359.

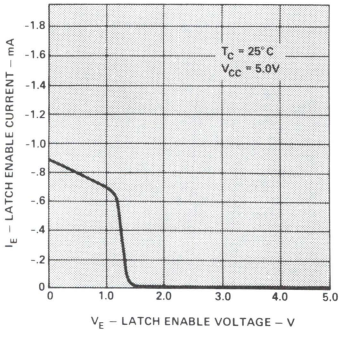


Figure 5. Typical Latch Enable Input Current vs. Voltage.

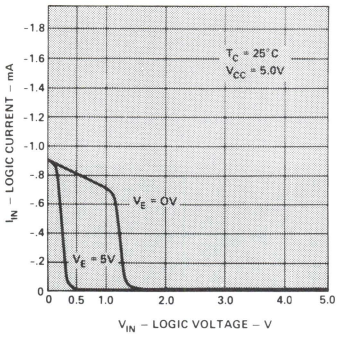


Figure 6. Typical Logic and Decimal Point Input Current vs. Voltage.

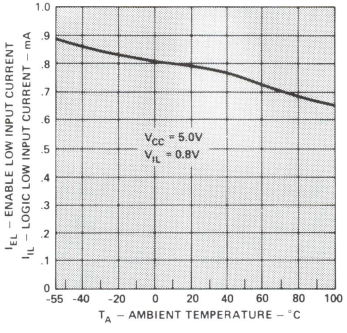


Figure 7. Typical Logic and Enable Low Input Current vs. Ambient Temperature.

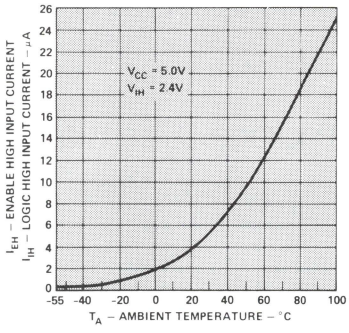


Figure 8. Typical Logic and Enable High Input Current vs. Ambient Temperature.

Operational Considerations

ELECTRICAL

The 5082-735X series devices use a modified 4 x 7 dot matrix of light emitting diodes (LED's) to display decimal/hexadecimal numeric information. The LED's are driven by constant current drivers. BCD information is accepted by the display memory when the enable line is at logic low and the data is latched when the enable is at logic high. To avoid the latching of erroneous information, the enable pulse rise time should not exceed 200 nanoseconds. Using the enable pulse width and data setup and hold times listed in the Recommended Operating Conditions allows data to be clocked into an array of displays at a 6.7MHz rate.

The blanking control input on the 5082-7395 display blanks (turns off) the displayed hexadecimal information without disturbing the contents of display memory. The display is blanked at a minimum threshold level of 3.5 volts. This may be easily achieved by using an open collector TTL gate and a pull-up resistor. For example, (1/6) 7416 hexinverter buffer/driver and a 120 ohm pull-up resistor will provide sufficient drive to blank eight displays. The size of the blanking pull-up resistor may be calculated from the following formula, where N is the number of digits:

$$R_{blank} = (V_{CC} - 3.5V)/[N\ (1.0mA)]$$

The decimal point input is active low true and this data is latched into the display memory in the same fashion as is the BCD data. The decimal point LED is driven by the on-board IC.

The ESD susceptibility of these IC devices is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263.

MECHANICAL

These displays are designed for use in adverse industrial environments.

These displays may be mounted by soldering directly to a printed circuit board or inserted into a socket. The lead-to-lead pin spacing is 2.54mm (0.100 inch) and the lead row spacing is 15.24mm (0.600 inch). These displays may be end stacked with 2.54mm (0.100 inch) spacing between outside pins of adjacent displays. Sockets such as Augat 324-AG2D (3 digits) or Augat 508-AG8D (one digit, right angle mounting) may be used.

The primary thermal path for power dissipation is through the device leads. Therefore, to insure reliable operation up to an ambient temperature of +100° C, it is important to maintain a case-to-ambient thermal resistance of less than 35° C/watt as measured on top of display pin 3.

Post solder cleaning may be accomplished using water, Freon/alcohol mixtures formulated for vapor cleaning processing (up to 2 minutes in vapors at boiling) or Freon/alcohol mixtures formulated for room temperature cleaning. Suggested solvents: Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15.

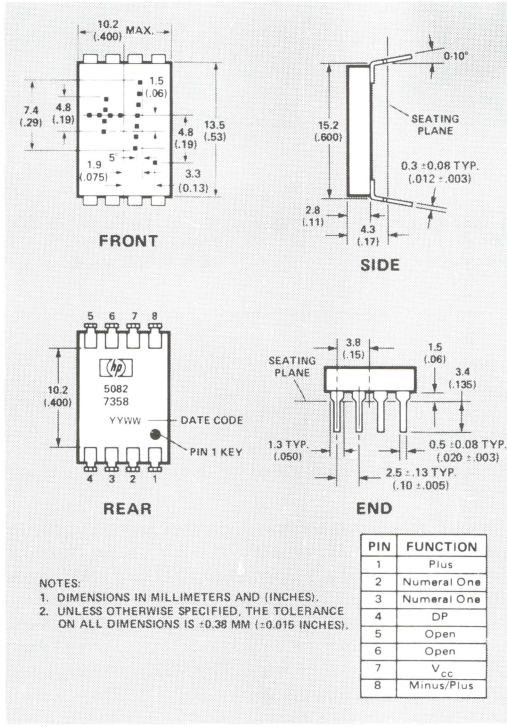
CONTRAST ENHANCEMENT

The 5082-735X displays have been designed to provide the maximum posible ON/OFF contrast when placed behind an appropriate contrast enhancement filter. Some suggested filters are Panelgraphic Ruby Red 60 and Dark Red 63, SGL Homalite H100-1605, 3M Light Control Film and Polaroid HRCP Red Circular Polarizing Filter. For further information see Hewlett-Packard Application Note 964.

Solid State Over Range Display

For display applications requiring a ±, 1, or decimal point designation, the 5082-7358 over range display is available. This display module comes in the same package as the 5082-735X series numeric display and is completely compatible with it.

Package Dimensions



PIN	FUNCTION
1	Plus
2	Numeral One
3	Numeral One
4	DP
5	Open
6	Open
7	V_{cc}
8	Minus/Plus

NOTES:
1. DIMENSIONS IN MILLIMETERS AND (INCHES).
2. UNLESS OTHERWISE SPECIFIED, THE TOLERANCE ON ALL DIMENSIONS IS ±0.38 MM (±0.015 INCHES).

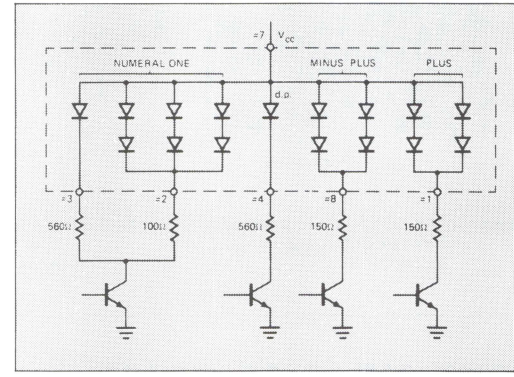


Figure 9. Typical Driving Circuit.

TRUTH TABLE

CHARACTER	PIN			
	1	2,3	4	8
+	H	X	X	H
–	L	X	X	H
1	X	H	X	X
Decimal Point	X	X	H	X
Blank	L	L	L	L

NOTES: L: Line switching transistor in Figure 9 cutoff.
H: Line switching transistor in Figure 9 saturated.
X: 'Don't care'

Electrical/Optical Characteristics

5082-7358 (T_A = -55°C to +85°C, Unless Otherwise Specified)

DESCRIPTION	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Forward Voltage per LED	V_F	I_F = 10 mA		1.6	2.0	V
Power dissipation	P_T	I_F = 10 mA all diodes lit		280	320	mW
Luminous Intensity per LED (digit average)	I_v	I_F = 6 mA T_C = 25°C	40	85		μcd
Peak wavelength	$\lambda peak$	T_C = 25°C		655		nm
Dominant Wavelength	λd	T_C = 25°C		640		nm
Weight				1.0		gm

Recommended Operating Conditions

	SYMBOL	MIN	NOM	MAX	UNIT
LED supply voltage	V_{CC}	4.5	5.0	5.5	V
Forward current, each LED	I_F		5.0	10	mA

NOTE:
LED current must be externally limited. Refer to Figure 9 for recommended resistor values.

Absolute Maximum Ratings

DESCRIPTION	SYMBOL	MIN.	MAX.	UNIT
Storage temperature, ambient	T_S	-65	+125	°C
Operating temperature, ambient	T_A	-55	+100	°C
Forward current, each LED	I_F		10	mA
Reverse voltage, each LED	V_R		4	V

HEWLETT PACKARD

HEXADECIMAL AND NUMERIC DISPLAYS FOR INDUSTRIAL APPLICATIONS

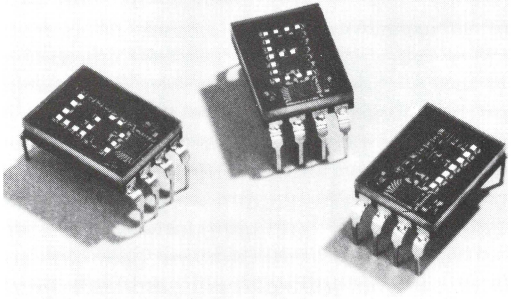
HIGH EFFICIENCY RED	
Low Power	HDSP-0760/0761/0762/0763
High Brightness	HDSP-0770/0771/0772/0763
YELLOW	HDSP-0860/0861/0862/0863
GREEN	HDSP-0960/0961/0962/0963

Features

- **THREE COLORS**
  High-Efficiency Red
  Yellow
  High Performance Green
- **THREE CHARACTER OPTIONS**
  Numeric
  Hexadecimal
  Over Range
- **TWO HIGH-EFFICIENCY RED OPTIONS**
  Low Power
  High Brightness
- **PERFORMANCE GUARANTEED OVER TEMPERATURE**
- **MEMORY LATCH/DECODER/DRIVER TTL Compatible**
- **4x7 DOT MATRIX CHARACTER**
- **CATEGORIZED FOR LUMINOUS INTENSITY**
- **YELLOW AND GREEN CATEGORIZED FOR COLOR**

Typical Applications

- **INDUSTRIAL EQUIPMENT**
- **COMPUTER PERIPHERALS**
- **INSTRUMENTATION**
- **TELECOMMUNICATION EQUIPMENT**



Description

These solid state display devices are designed and tested for use in adverse industrial environments. The character height is 7.4mm (0.29 inch). The numeric and hexadecimal devices incorporate an on-board IC that contains the data memory, decoder and display driver functions.

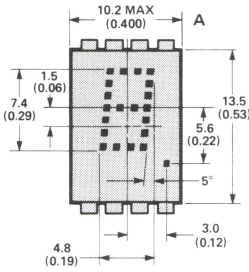
The numeric devices decode positive BCD logic into characters "0-9", a "—" sign, decimal point, and a test pattern. The hexadecimal devices decode positive BCD logic into 16 characters, "0-9, A-F". An input is provided on the hexadecimal devices to blank the display (all LED's off) without losing the contents of the memory.

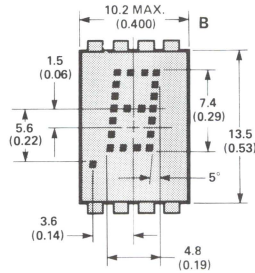
The over range device displays "±1" and right hand decimal point and is typically driven via external switching transistors.

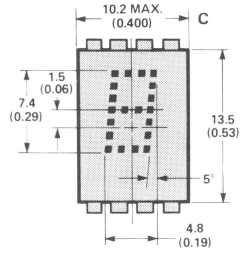
Devices

Part Number HDSP-	Color	Description	Front View
0760	High-Efficiency Red Low Power	Numeric, Right Hand DP	A
0761		Numeric, Left Hand DP	B
0762		Hexadecimal	C
0763		Over Range ±1	D
0770	High-Efficiency Red High Brightness	Numeric, Right Hand DP	A
0771		Numeric, Left Hand DP	B
0772		Hexadecimal	C
0763		Over Range ±1	D
0860	Yellow	Numeric, Right Hand DP	A
0861		Numeric, Left Hand DP	B
0862		Hexadecimal	C
0863		Over Range ±1	D
0960	Green	Numeric, Right Hand DP	A
0961		Numeric, Left Hand DP	B
0962		Hexadecimal	C
0963		Over Range ±1	D

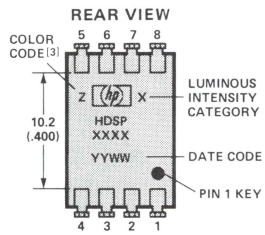
Package Dimensions

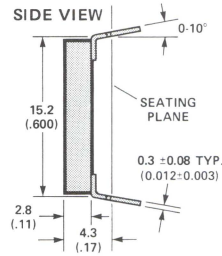


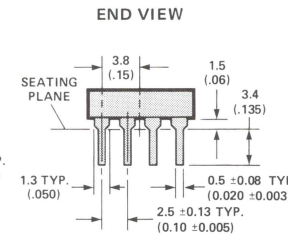




PIN	FUNCTION	
	NUMERIC	HEXA-DECIMAL
1	Input 2	Input 2
2	Input 4	Input 4
3	Input 8	Input 8
4	Decimal point	Blanking control
5	Latch enable	Latch enable
6	Ground	Ground
7	V_{CC}	V_{CC}
8	Input 1	Input 1







NOTES:
1. Dimensions in millimetres and (inches).
2. Digit center line is ±0.38 mm (±0.015 inch) from package center line.
3. Unless otherwise specified, the tolerance on all dimensions is ±0.38 mm (±0.015 inch).
4. HDSP-0860 and HDSP-0960 series.

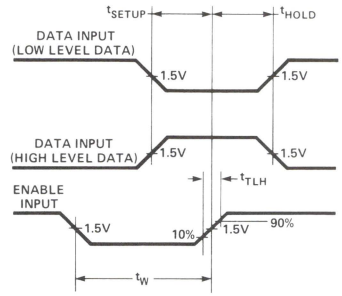


Figure 1. Timing Diagram

TRUTH TABLE					
BCD DATA[1]				NUMERIC	HEXA-DECIMAL
X_8	X_4	X_2	X_1		
L	L	L	L	0	0
L	L	L	H	1	1
L	L	H	L	2	2
L	L	H	H	3	3
L	H	L	L	4	4
L	H	L	H	5	5
L	H	H	L	6	6
L	H	H	H	7	7
H	L	L	L	8	8
H	L	L	H	9	9
H	L	H	L		A
H	L	H	H	(BLANK)	B
H	H	L	L	(BLANK)	C
H	H	L	H	-	D
H	H	H	L	(BLANK)	E
H	H	H	H	(BLANK)	F
DECIMAL PT.[2]			ON		V_{DP} = L
			OFF		V_{DP} = H
ENABLE[1]			LOAD DATA		V_E = L
			LATCH DATA		V_E = H
BLANKING[3]			DISPLAY-ON		V_B = L
			DISPLAY-OFF		V_B = H

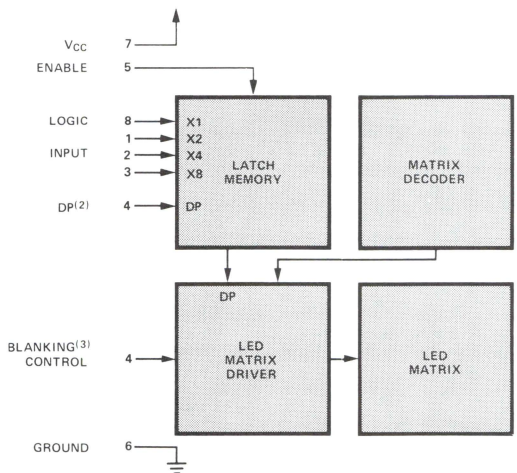


Figure 2. Logic Block Diagram

Notes:
1. H = Logic High; L = Logic Low. With the enable input at logic high changes in BCD input logic levels have no effect upon display memory, displayed character, or DP.
2. The decimal point input, DP, pertains only to the numeric displays.
3. The blanking control input, B, pertains only to the hexadecimal displays. Blanking input has no effect upon display memory.

Absolute Maximum Ratings

Description	Symbol	Min.	Max.	Unit
Storage temperature, ambient	T_S	−65	+100	°C
Operating temperature, ambient [1]	T_A	−55	+85	°C
Supply voltage [2]	V_{CC}	−0.5	+7.0	V
Voltage applied to input logic, dp and enable pins	V_I, V_{DP}, V_E	−0.5	V_{CC}	V
Voltage applied to blanking input [2]	V_B	−0.5	V_{CC}	V
Maximum solder temperature at 1.59mm (.062 inch) below seating plane; t ≤ 5 seconds			260	°C

Recommended Operating Conditions

Description	Symbol	Min.	Nom.	Max.	Unit
Supply Voltage [2]	V_{CC}	4.5	5.0	5.5	V
Operating temperature, ambient [1]	T_A	-55		+85	°C
Enable Pulse Width	t_W	100			nsec
Time data must be held before positive transition of enable line	t_{SETUP}	50			nsec
Time data must be held after positive transition of enable line	t_{HOLD}	50			nsec
Enable pulse rise time	t_{TLH}			1.0	msec

Optical Characteristics at T_A = 25°C, V_{CC} = 5.0V

Device	Description	Symbol	Min.	Typ.	Max.	Unit
HDSP-0760 Series	Luminous Intensity per LED (Digit Average) [3,4]	I_V	65	140		μcd
	Peak Wavelength	λ_{PEAK}		635		nm
	Dominant Wavelength [5]	λ_d		626		nm
HDSP-0770 Series	Luminous Intensity per LED (Digit Average) [3,4]	I_V	260	620		μcd
	Peak Wavelength	λ_{PEAK}		635		nm
	Dominant Wavelength [5]	λ_d		626		nm
HDSP-0860 Series	Luminous Intensity per LED (Digit Average) [3,4]	I_V	215	490		μcd
	Peak Wavelength	λ_{PEAK}		583		nm
	Dominant Wavelength [5,6]	λ_d		585		nm
HDSP-0960 Series	Luminous Intensity per LED (Digit Average) [3,4]	I_V	298	1100		μcd
	Peak Wavelength	λ_{PEAK}		568		nm
	Dominant Wavelength [5,6]	λ_d		574		nm

Notes:
1. The nominal thermal resistance of a display mounted in a socket that is soldered onto a printed circuit board is $R\theta_{JA}$ = 50° C/W/device. The device package thermal resistance is $R\theta_{J-PIN}$ = 15° C/W/device. The thermal resistance device pin-to-ambient through the PC board should not exceed 35° C/W/device for operation at T_A = +85° C.
2. Voltage values are with respect to device ground, pin 6.
3. These displays are categorized for luminous intensity with the intensity category designated by a letter code located on the back of the display package. Case temperature of the device immediately prior to the light measurement is equal to 25° C.

Electrical Characteristics; T_A = -55°C to +85°C

Description		Symbol	Test Conditions	Min.	Typ.[7]	Max.	Unit
Supply Current	HDSP-0760 Series	I_{CC}	V_{CC} = 5.5V (characters "5." or "B" displayed)		78	105	mA
	HDSP-0770 Series HDSP-0860 Series HDSP-0960 Series				120	175	
Power Dissipation	HDSP-0760 Series	P_T			390	573	mW
	HDSP-0770 Series HDSP-0860 Series HDSP-0960 Series				690	963	
Logic, Enable and Blanking Low-Level Input Voltage		V_{IL}	V_{CC} = 4.5V			0.8	V
Logic, Enable and Blanking High-Level Input Voltage		V_{IH}		2.0			V
Logic and Enable Low-Level Input Current		I_{IL}	V_{CC} = 5.5V			-1.6	mA
Blanking Low-Level Input Current		I_{BL}	V_{IL} = 0.4V			-10	μA
Logic, Enable and Blanking High-Level Input Current		I_{IH}	V_{CC} = 5.5V V_{IH} = 2.4V			+40	μA
Weight					1.0		gm
Leak Rate						$5x10^{-8}$	cc/sec

Notes:

4. The luminous intensity at a specific operating ambient temperature, $I_V(T_A)$ may be approximated from the following expotential equation: $I_V(T_A) = I_V(25°C)\, e^{|K(T_A - 25°C)|}$.

Device	K
HDSP-0760 Series HDSP-0770 Series	-0.0131/° C
HDSP-0860 Series	-0.0112/° C
HDSP-0960 Series	-0.0104/° C

5. The dominant wavelength, λ_d, is derived from the CIE Chromaticity Diagram and is that single wavelength which defines the color of the device.
6. The HDSP-0860 and HDSP-0960 series devices are categorized as to dominant wavelength with the category designated by a number on the back side of the display package.
7. All typical values at V_{CC} = 5.0V and T_A = 25° C.

Operational Considerations

ELECTRICAL

These devices use a modified 4 x 7 dot matrix of light emitting diode to display decimal/hexadecimal numeric information. The high efficiency red and yellow LED's are GaAsP epitaxial layer on a GaP transparent substrate. The green LED's are GaP epitaxial layer on a GaP transparent substrate. The LED's are driven by constant current drivers, BCD information is accepted by the display memory when the enable line is at logic low and the data is latched when the enable is at logic high. Using the enable pulse width and data setup and hold times listed in the Recommended Operating Conditions allows data to be clocked into an array of displays at a 6.7 MHz rate.

The decimal point input is active low true and this data is latched into the display memory in the same fashion as the BCD data. The decimal point LED is driven by the on-board IC.

The blanking control input on the hexadecimal displays blanks (turns off) the displayed information without disturbing the contents of display memory. The display is blanked at a minimum threshold level of 2.0 volts. When blanked, the display standby power is nominally 250 mW at T_A = 25° C.

MECHANICAL

The primary thermal path for power dissipation is through the device leads. Therefore, to insure reliable operation up to an ambient temperature of +85° C, it is important to maintain a cast-to-ambient thermal resistance of less than 35° C watt/device as measured on top of display pin 3.

Post solder cleaning may be accomplished using water, Freon/alcohol mixtures formulated for vapor cleaning processing (up to 2 minutes in vapors at boiling) or Freon/alcohol mixutres formulated for room temperature cleaning. Suggested solvents: Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15.

CONTRAST ENHANCEMENT

These display devices are designed to provide an optimum ON/OFF contrast when placed behind an appropriate contrast enhancement filter. The following filters are suggested:

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
HDSP-0860 Series Yellow	Panelgraphic Yellow 27 Chequers Amber 107	Polaroid HNCP 37 3M Light Control Film Panelgraphic Gray 10 Chequers Grey 105	Polaroid Gray HNCP10 HOYA Yellowish-Orange HLF-608-3Y Marks Gray MCP-0301-8-10
HDSP-0760 Series HDSP-0770 Series High Efficiency Red	Panelgraphic Ruby Red 60 Chequers Red 112		Polaroid Gray HNCP10 HOYA Reddish-Orange HLF-608-5R Marks Gray MCP-0301-8-10 Marks Reddish-Orange MCP-0201-2-22
HDSP-0960 Series HP Green	Panelgraphic Green 48 Chequers Green 107		Polaroid Gray HNCP10 HOYA Yellow-Green HLF-608-1G Marks Yellow-Green MCP-0101-5-12

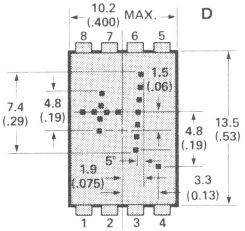
Over Range Display

The over range devices display "±1" and decimal point. The character height and package configuration are the same as the numeric and hexadecimal devices. Character selection is obtained via external switching transistors and current limiting resistors.

Absolute Maximum Ratings

Description	Symbol	Min.	Max.	Unit
Storage Temperature, Ambient	T_S	-65	+100	°C
Operating Temperature Ambient	T_A	-55	+85	°C
Forward Current, Each LED	I_F		10	mA
Reverse Voltage, Each LED	V_R		5	V

Package Dimensions



FRONT VIEW

Pin	Function
1	Plus
2	Numeral One
3	Numeral One
4	DP.
5	Open
6	Open
7	V_{CC}
8	Minus/Plus

Note:
1. Dimensions in millimetres and (inches).

Character	Pin			
	1	2,3	4	8
+	1	X	X	1
—	0	X	X	1
1	X	1	X	X
Decimal Point	X	X	1	X
Blank	0	0	0	0

Notes:
0: Line switching transistor in Figure 7 cutoff.
1: Line switching transistor in Figure 7 saturated.
X: 'don't care'

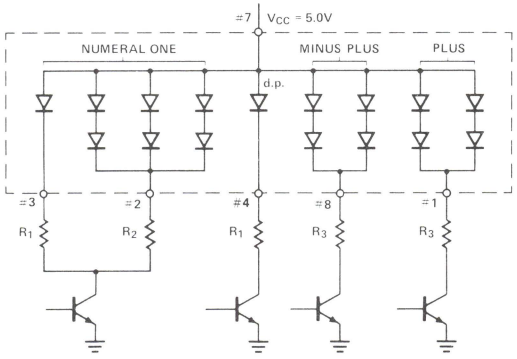


Figure 3. Typical Driving Circuit

Recommended Operating Conditions V_{CC} = 5.0V

Device		Forward Current Per LED, mA	Resistor Value		
			R_1	R_2	R_3
HDSP-0763	Low Power	2.8	1300	200	300
	High Brightness	8	360	47	68
HDSP-0863		8	360	36	56
HDSP-0963		8	360	30	43

Luminous Intensity Per LED

(Digit Average)[3,4] at T_A = 25°C

Device	Test Conditions	Min.	Typ.	Units
HDSP-0763	I_F = 2.8 mA	65	140	μcd
	I_F = 8 mA		620	μcd
HDSP-0863	I_F = 8 mA	215	490	μcd
HDSP-0963	I_F = 8 mA	298	1100	μcd

Electrical Characteristics; T_A = -55°C to +85°C

Device	Description	Symbol	Test Condition	Min.	Typ.	Max.	Units
HDSP-0763	Power Dissipation (all LED's Illuminated)	P_T	I_F = 2.8 mA		72		mW
			I_F = 8 mA		224	282	
	Forward Voltage per LED	V_F	I_F = 2.8 mA		1.6		V
			I_F = 8 mA		1.75	2.2	
HDSP-0863	Power Dissipation (all LED's Illuminated)	P_T	I_F = 8 mA		237	282	mW
	Forward Voltage per LED	V_F			1.90	2.2	V
HDSP-0963	Power Dissipation (all LED's Illuminated)	P_T	I_F = 8 mA		243	282	mW
	Forward Voltage per LED	V_F			1.85	2.2	V

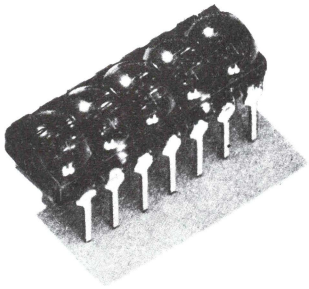
HEWLETT PACKARD

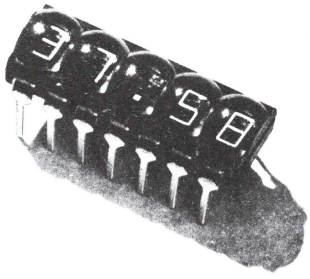
LEADFRAME MOUNTED SEVEN SEGMENT MONOLITHIC NUMERIC INDICATORS

5082-7400/7430 SERIES

Features

- **COMPACT PACKAGE SIZES**
  .25" Package Width
  .150" and .200" Digit Spacing
- **STROBED OPERATION**
  Minimizes Lead Connections
- **FULLY ENCAPSULATED STANDARD DIP PACKAGES**
  End Stackable
  Integral Red Filter
  Extremely Rugged Construction
- **I.C. COMPATIBLE**
- **CATEGORIZED FOR LUMINOUS INTENSITY**
  Assures uniformity of light output from unit to unit within single category.





Description

The HP 5082-7400/-7430 series are 2.79 mm (.11"), seven segment GaAsP numeric indicators packaged in 2, 3, 4 and 5 digit clusters. An integral magnification technique increases the luminous intensity, thereby making low power consumption possible. Options include either the standard lower right hand decimal point or a centered decimal point.

Applications include mobile telephones, hand held calculators, portable instruments and many other products requiring compact, rugged, long lifetime active indicators.

Device Selection Guide

Digits per Cluster	Configuration Device	Inter-Digit Spacing mm (inches)	Part Number Center Decimal Point	 Right Decimal Point
2 (right)		5.08 (.200)		5082-7432
3		5.08 (.200)		5082-7433
4		3.81 (.150)	5082-7404	5082-7414
5		3.81 (.150)	5082-7405	5082-7415

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units
Peak Forward Current per Segment or dp (Duration < 500 μs) 5082-7432/7433	I_{PEAK}		50	mA
Peak Forward Current per Segment or dp (Duration < 1 msec) 5082-7404/7405/7414/7415	I_{PEAK}		110	mA
Average Current per Segment or dp	I_{AVG}		5	mA
Power Dissipation per Digit[1]	P_D		80	mW
Operating Temperature, Ambient	T_A	-40	75	°C
Storage Temperature	T_S	-40	100	°C
Reverse Voltage	V_R		5	V
Solder Temperature 1/16" below seating plane (t ≤ 3 sec)[2]			230	°C

Notes: 1. Derate linearly @ 1 mW/°C above 25°C ambient.
2. See Mechanical section for recommended flux removal solvents.

Electrical/Optical Characteristics at $T_A = 25°C$

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment or dp[3,4] 5082-7432/7433	I_V	I_{AVG} = 500 μA (I_{PK} = 5 mA duty cycle = 10%)	10	40		μcd
Luminous Intensity/Segment or dp[3,4] (Time Averaged) 5082-7404/7405/7414/7415	I_V	I_{AVG} = 1 mA I_{PK} = 10 mA duty cycle = 10%)	5	20		μcd
Peak Wavelength	λ_{PEAK}			655		nm
Forward Voltage/Segment or dp 5082-7432/-7433	V_F	I_F = 5 mA		1.55	2.0	V
Forward Voltage/Segment or dp 5082-7404/7405/7414/7415	V_F	I_F = 10 mA		1.55	2.0	V
Reverse Voltage/Segment or dp	V_R	I_R = 200 μA	5			V
Rise and Fall Time[5]	t_r, t_f			10		ns

NOTES:
3. The digits are categorized for luminous intensity. Intensity categories are designated by a letter located on the back side of the package.
4. Each character of the display is matched for luminous intensity at the test conditions shown. Operation of the display at lower peak currents may cause intensity mismatch within the display. Operation at peak currents less than 5.0 mA may cause objectionable display segment matching.
5. Time for a 10%-90% change of light intensity for step change in current.

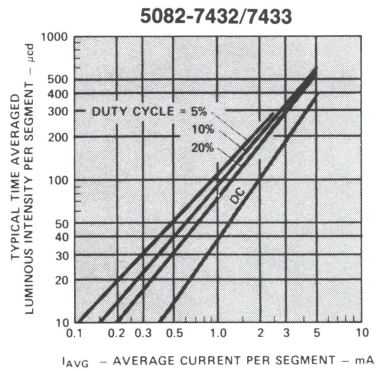


Figure 1. Typical Time Averaged Luminous Intensity per Segment (Digit Average) vs. Current per Segment.

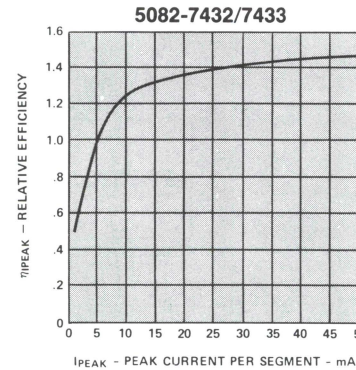


Figure 2. Relative Luminous Efficiency vs. Peak Current per Segment.

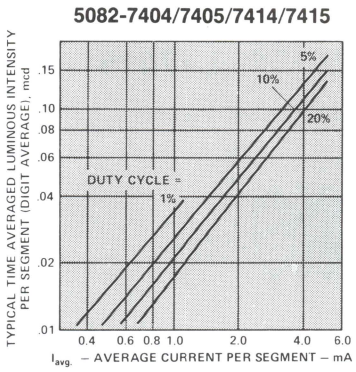


Figure 3. Typical Time Averaged Luminous Intensity per Segment (Digit Average) vs. Average Current per Segment.

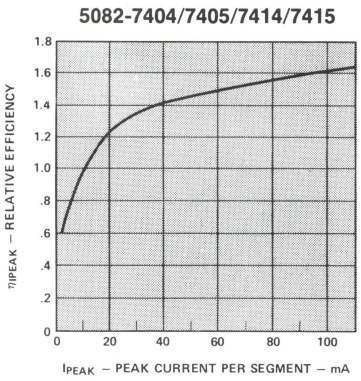


Figure 4. Relative Luminous Efficiency vs. Peak Current per Segment.

5082-7400/7430 SERIES

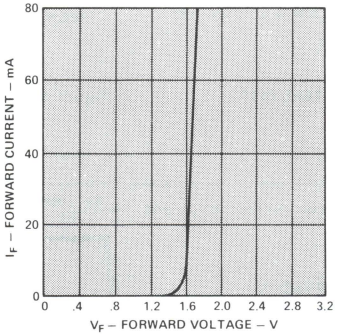


Figure 5. Forward Current vs. Forward Voltage.

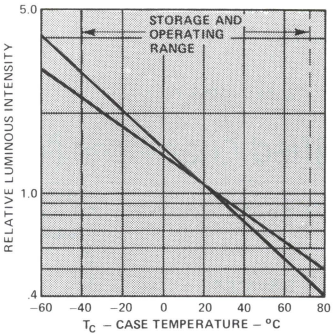


Figure 6. Relative Luminous Intensity vs. Case Temperature at Fixed Current Level.

Electrical/Optical

The 5082-7400/7430 series devices utilize a monolithic GaAsP chip of 8 common cathode segments for each display digit. The segment anodes of each digit are interconnected, forming an 8 by N line array, where N is the number of characters in the display. Each chip is positioned under an integrally molded lens giving a magnified character height of 2.79mm (0.11) inches. Satisfactory viewing will be realized within an angle of ±30° for the 7404/7405/7414/7415 and ±20° for the 7432/7433, measured from the center line of the digit.

The decimal point in the 7432, 7433, 7414, and 7415 displays is located at the lower right of the digit for conventional driving schemes.

The 5082-7404 and 7405 displays contain a centrally located decimal point which is activated in place of a digit. In long registers, this technique of setting off the decimal point significantly improves the display's readability. With respect to timing, the decimal point is treated as a separate character with its own unique time frame.

To improve display contrast, the plastic incorporates a red dye that absorbs strongly at all visible wavelengths except the 655 nm emitted by the LED. An additional filter, such as Plexiglass 2423, Panelgraphic 60 or 63, and SGL Homalite 100-1605, will further lower the ambient reflectance and improve display contrast.

Mechanical

The 5082-7400/7430 series package is a standard 12 or 14 Pin DIP consisting of a plastic encapsulated lead frame with integral molded lenses. It is designed for plugging into DIP sockets or soldering into PC boards. The lead frame construction allows use of standard DIP insertion tools and techniques. Alignment problems are simplified due to the clustering of digits in a single package. The shoulders of the lead frame pins are intentionally raised above the bottom of the package to allow tilt mounting of up to 20° from the PC board.

To optimize device optical performance, specially developed plastics are used which restrict the solvents that may be used for cleaning. It is recommended that only mixtures of Freon (F113) and alcohol be used for vapor cleaning processes, with an immersion time in the vapors of less than two (2) minutes maximum. Some suggested vapor cleaning solvents are Freon TE, Genesolv DI-15 or DE-15, Arklone A or K. A 60°C (140°C) water cleaning process may also be used, which includes a neutralizer rinse (3% ammonia solution or equivalent), a surfactant rinse (1% detergent solution or equivalent), a hot water rinse and a thorough air dry. Room temperature cleaning may be accomplished with Freon T-E35 or T-P35, Ethanol, Isopropanol or water with a mild detergent.

Package Description 5082-7404, -7405, -7414, -7415

Notes: 6. Dimensions in millimeters and (inches).
7. Tolerances on all dimension are ±.38 mm (±.015 in.) unless otherwise noted.

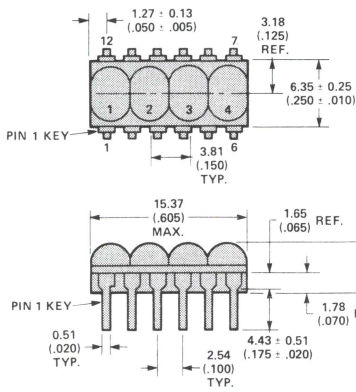


Figure 7. 5082-7404/7414

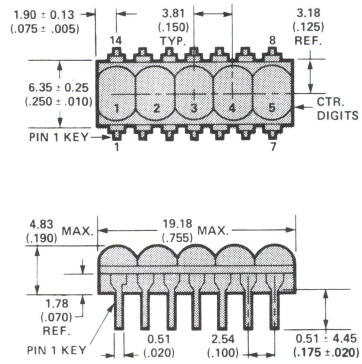


Figure 8. 5082-7405/7415.

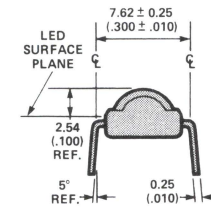


Figure 9. 5082-7404/7405/7414/7415

Magnified Character Font Description

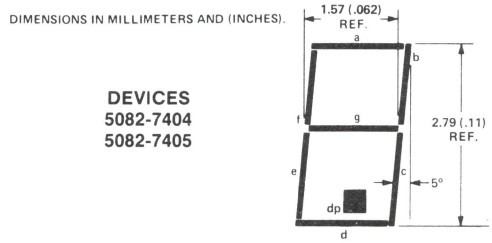


Figure 10. Center Decimal Point Configuration

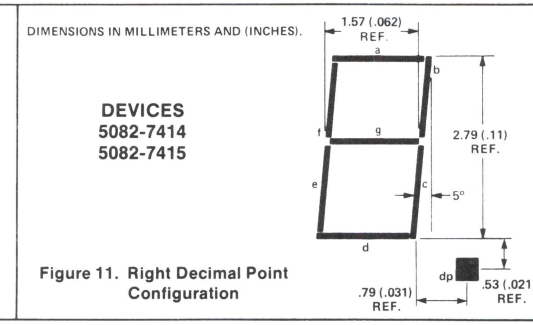


Figure 11. Right Decimal Point Configuration

Device Pin Description

PIN NO.	5082-7404/7414 FUNCTION	5082-7405/7415 FUNCTION
1	CATHODE 1	CATHODE 1
2	ANODE e	ANODE e
3	ANODE c	ANODE c
4	CATHODE 3	CATHODE 3
5	ANODE dp	ANODE dp
6	CATHODE 4	ANODE d
7	ANODE g	CATHODE 5
8	ANODE d	ANODE g
9	ANODE f	CATHODE 4
10	CATHODE 2	ANODE f
11	ANODE b	SEE NOTE 8
12	ANODE a	ANODE b
13	—	CATHODE 2
14	—	ANODE a

Note 8: Leave Pin Unconnected.

Package Description 5082-7432, -7433

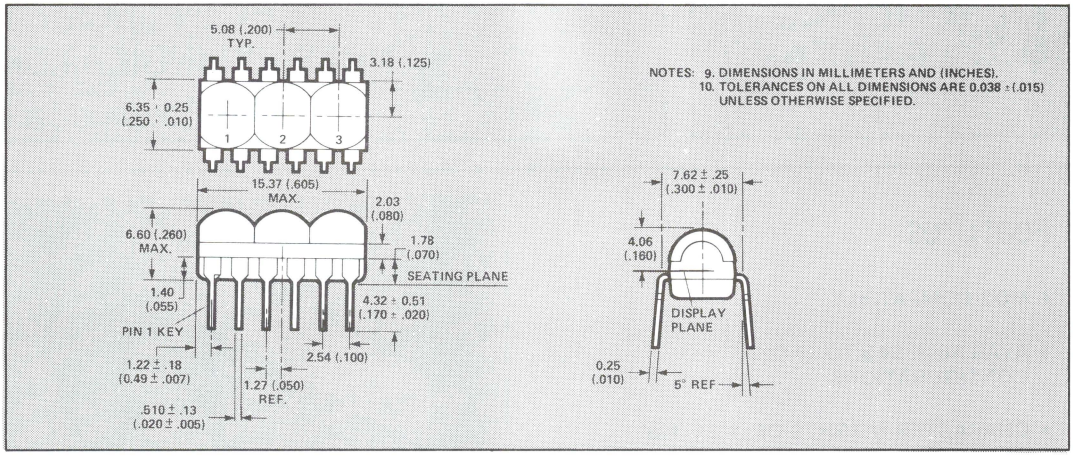


Figure 11.

Magnified Character Font Description

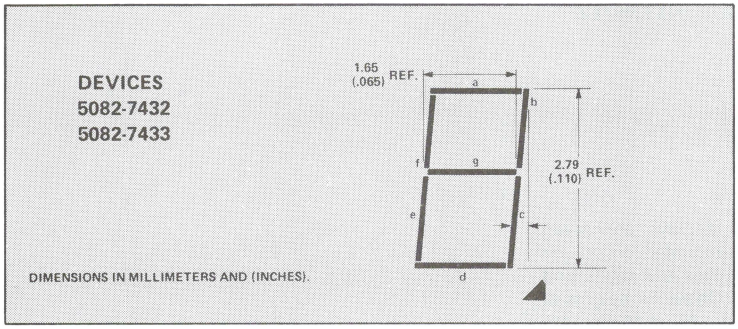


Figure 12.

Device Pin Description

PIN NUMBER	5082-7432 FUNCTION	5082-7433 FUNCTION
1	SEE NOTE 11.	CATHODE 1
2	ANODE e	ANODE e
3	ANODE d	ANODE d
4	CATHODE 2	CATHODE 2
5	ANODE c	ANODE c
6	ANODE dp	ANODE dp
7	CATHODE 3	CATHODE 3
8	ANODE b	ANODE b
9	ANODE g	ANODE g
10	ANODE a	ANODE a
11	ANODE f	ANODE f
12	SEE NOTE 11.	SEE NOTE 11.

NOTE 11. Leave Pin unconnected.

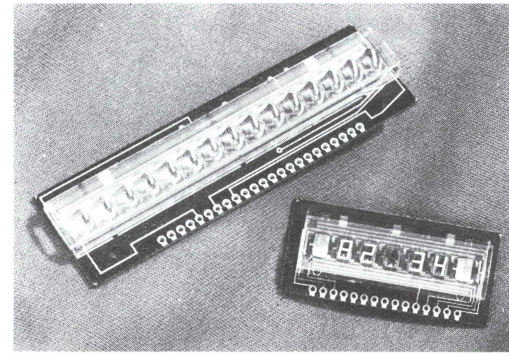
HEWLETT PACKARD

PRINTED CIRCUIT BOARD MOUNTED SEVEN SEGMENT NUMERIC INDICATORS

5082-7200/7440 SERIES

Features

- **MOS COMPATIBLE**
- **AVAILABLE IN 9 TO 16 DIGIT CONFIGURATIONS**
- **CHARACTER HEIGHTS OF .105", .115" AND .175"**
- **LOW POWER**
- **CATEGORIZED FOR LUMINOUS INTENSITY**



Description

The HP-5082-7200/7440 series of displays are seven segment GaAsP Numeric Indicators mounted on printed circuit boards. A plastic lens magnifies the digits and includes an integral protective bezel. Character heights of .105" (2.67 mm), .115" (2.92 mm) and .175" (4.45 mm) are available. For large quantity applications, digit string lengths of 8, 12 and 14 digits are available by special order.

Applications are hand held calculators and portable equipment requiring compact, low power, long life time, active displays.

Device Selection Guide

Part Number	Digits Per PC Board	Decimal Point	Package	Character Height (mm) in.	Inter-Digit Spacing (mm) in.
5082-7441	9	Right Hand	Fig. 9	(2.67) .105"	(5.08) .200"
5082-7446	16	Right Hand	Fig. 11	(2.92) .115"	(3.81) .150"
5082-7285	5	Right Hand	Fig. 14	(4.45) .175"	(5.84) .230"
5082-7295	15	Right Hand	Fig. 13	(4.45) .175"	(5.84) .230"

Maximum Ratings 5082-7441/7446

Parameter	Symbol	Min.	Max.	Units
Peak Forward Current per Segment or dp (Duration < 500μs)	I_{PEAK}		50	mA
Average Current per Segment or dp[1]	I_{AVG}		3	mA
Power Dissipation per Digit [2]	P_D		50	mW
Operating Temperature, Ambient	T_A	-20	+85	°C
Storage Temperature	T_S	-20	+85	°C
Reverse Voltage	V_R		3	V
Solder Temperature at connector edge (t≤3 sec.)[3]			230	°C

NOTES: 1. Derate linearly at 0.1mA/°C above 60°C ambient.
2. Derate linearly at 1.7mW/°C above 60°C ambient.
3. See Mechanical section for recommended soldering techniques and flux removal solvents.

Maximum Ratings 5082-7285/7295

Parameter	Symbol	Min.	Max.	Units
Peak Forward Current per Segment or DP (Duration <35μs)	I_{PEAK}		200	mA
Average Current per Segment or DP (4)	I_{AVG}		7	mA
Power Dissipation per Digit (5)	P_D		125	mW
Operating Temperature, Ambient	T_A	-20	+70	°C
Storage Temperature	T_S	-20	+80	°C
Reverse Voltage	V_R		3	V
Solder Temperature at connector edge (t≤3 sec.) (6)			230	°C

NOTES: 4. Derate linearly at 0.12mA/°C above 25°C ambient.
5. Derate linearly at 2.3mW/°C above 25°C ambient.
6. See Mechanical section for recommended soldering techniques and flux removal solvents.

Electrical/Optical Characteristics at T_A = 25°C 5082-7441/7446

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment or dp[7] 5082-7441	I_V	I_{AVG} = 500μA (I_{PK} = 5mA duty cycle = 10%)	9	40		μcd
5082-7446		5mA Peak 1/16 Duty Cycle	7	35		μcd
Peak Wavelength	λ_{peak}			655		nm
Forward Voltage/Segment or dp	V_F	I_F = 5mA		1.55		V

NOTES:
7. Each character of the display is matched for luminous intensity at the test conditions shown. Operation of the display at lower peak currents may cause intensity mismatch within the display. Operation at peak currents less than 3.5 mA may cause objectionable display segment matching.

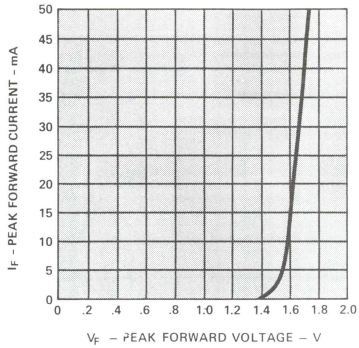


Figure 1. Peak Forward Current vs. Peak Forward Voltage.

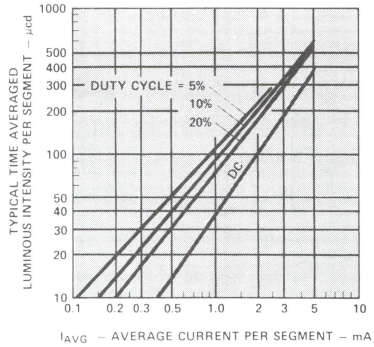


Figure 2. Typical Time Averaged Luminous Intensity per Segment vs. Average Current per Segment.

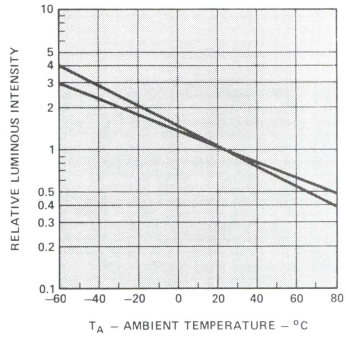


Figure 3. Relative Luminous Intensity vs. Ambient Temperature at Fixed Current Level.

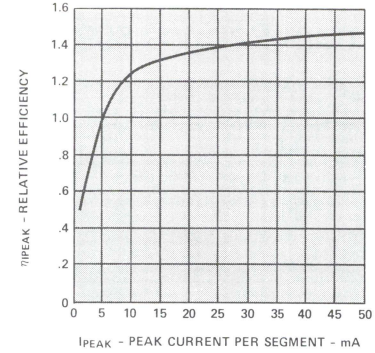


Figure 4. Relative Luminous Efficiency vs. Peak Current per Segment.

Electrical/Optical Characteristics at T_A=25°C 5082-7285/7295

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Luminous Intensity/Segment or dp (Time Averaged) 15 digit display 5082-7295[8,10]	I_v	$I_{avg.}$ = 2 mA (30 mA Peak 1/15 duty cycle)	30	90		μcd
Luminous Intensity/Segment or dp (Time Averaged) 5 digit display 5082-7285[8,10]	I_v	$I_{avg.}$ = 2 mA (10 mA Peak 1/5 duty cycle)	30	70		μcd
Forward Voltage per Segment or dp 5082-7295 15 digit display	V_F	I_F = 30 mA		1.60	2.3	V
Forward Voltage per Segment or dp 5082-7285 5 digit display	V_F	I_F = 10 mA		1.55	2.0	V
Peak Wavelength	λ_{PEAK}			655		nm
Dominant Wavelength[9]	λ_d			640		nm
Reverse Current per Segment or dp	I_R	V_R = 5V		10		μA
Temperature Coefficient of Forward Voltage	ΔV_F/°C			-2.0		mV/°C

NOTES:

8. The luminous intensity at a specific ambient temperature, I_V (T_A), may be calculated from this relationship: $I_V(T_A) = I_{V(25°C)}$ (.985) $^{(T_A - 25°C)}$.
9. The dominant wavelength, λ_d, is derived from the C.I.E. Chromaticity Diagram and represents the single wavelength which defines the color of the device.
10. Each character of the display is matched for luminous intensity at the test conditions shown. Operation of the display at lower peak currents may cause intensity mismatch within the display. Operation at peak currents less than 6.0 mA may cause objectionable display segment matching.

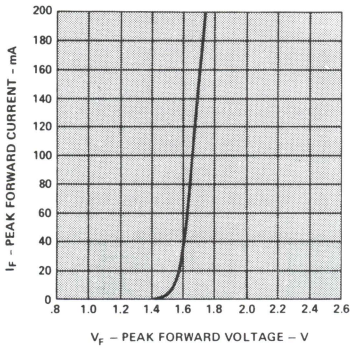


Figure 5. Peak Forward Current vs. Peak Forward Voltage.

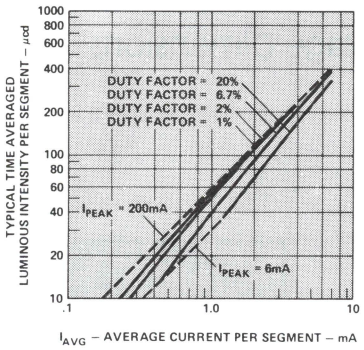


Figure 6. Typical Time Averaged Luminous Intensity per Segment vs. Average Current per Segment.

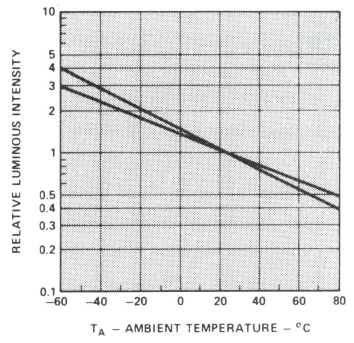


Figure 7. Relative Luminous Intensity vs. Ambient Temperature at Fixed Current Level.

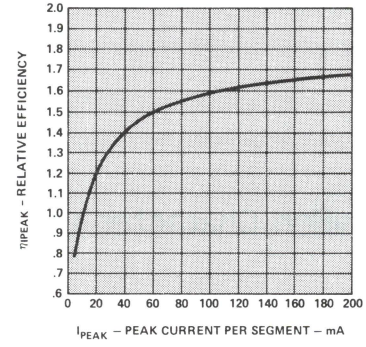


Figure 8. Relative Luminous Efficiency vs. Peak Current per Segment.

Mechanical

These devices are constructed on a standard printed circuit board substrate. A separately molded plastic lens is attached to the PC board over the digits. The lens is an acrylic styrene material that gives good optical lens performance, but is subject to scratching so care should be exercised in handling.

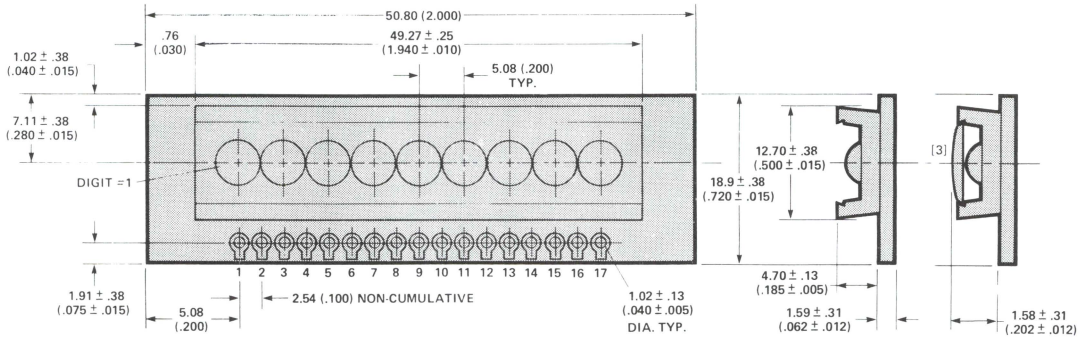
The device may be mounted either by use of pins which may be hand soldered into the plated through holes at the connector edge of the PC board or by insertion into a standard PC board connector. The devices may be hand soldered for up to 3 seconds per tab at a maximum soldering temperature of 230°C. Heat should be applied only to the edge connector tab areas of the PC board. Heating other areas of the board to temperatures in excess of 85°C can result in permanent damage to the display. It is recommended that a non-activated rosin core wire solder or a low temperature deactivating flux and solid wire solder be used in soldering operations.

The PC board is silver plated. To prevent the formation of a tarnish (Ag_2S) which could impair solderability the displays should be stored in the unopened shipping packages until they are used. Further information on the storage, handling, and cleaning of silver plated components is contained in Hewlett-Packard Application Bulletin No. 3.

Electrical/Optical

The HP 5082-7441, -7446, -7285 and 7295 devices utilize a monolithic GaAsP chip containing 7 segments and a decimal point for each display digit. The segments of each digit are interconnected, forming an 8 by N line array, where N is the number of digits in the display. Each chip is positioned under a separate element of a plastic magnifying lens, producing a magnified character. Satisfactory viewing will be realized within an angle of approximately ±20° from the centerline of the digit. A filter, such as plexiglass 2423, Panelgraphic 60 or 63, and Homalite 100-1600, will lower the ambient reflectance and improve display contrast. Digit encoding of these devices is performed by standard 7 segment decoder driver circuits.

Package Dimensions

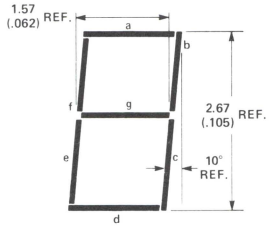


NOTES:
1. Dimensions in millimeters and (inches).
2. Logo and part number are on back of package.
3. Secondary 1.25X magnifier that slides into primary lens and increases character height to 3.33 (.131) available as special product.
4. Tolerances: ±.88 (.015)

Figure 9. 5082-7441

Magnified Character Font Description

5082-7441



Note: All dimensions in millimeters and (inches).

Figure 10.

Device Pin Description

Pin No.	5082-7441 Function	Pin No.	5082-7441 Function
1	Dig. 1 Cathode	10	Seg. d Anode
2	Seg. c Anode	11	Dig. 6 Cathode
3	Dig. 2 Cathode	12	Seg. g Anode
4	d.p. Anode	13	Dig. 7 Cathode
5	Dig. 3 Cathode	14	Seg. b Anode
6	Seg. a Anode	15	Dig. 8 Cathode
7	Dig. 4 Cathode	16	Seg. f Anode
8	Seg. e Anode	17	Dig. 9 Cathode
9	Dig. 5 Cathode		

Package Dimensions

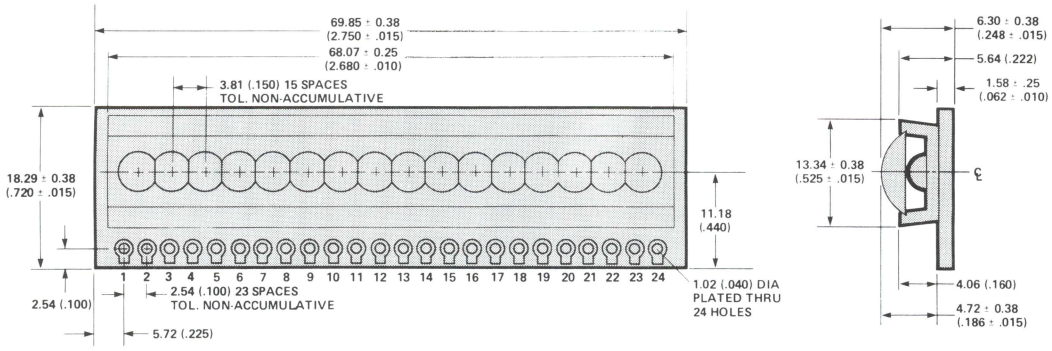
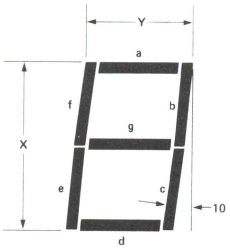


Figure 11. 5082-7446

Magnified Character Font Description



DEVICE	X	Y
5082-7446	2.92 (.115)	1.40 (.055)

NOTES: 1. ALL DIMENSIONS IN MILLIMETRES AND (INCHES).
2. TOLERANCES ON ALL DIMENSIONS ARE ±0.38 (.015) UNLESS OTHERWISE SPECIFIED.

Figure 12.

Device Pin Description

Pin No.	5082-7446 Function
1	Cathode-Digit 1
2	Cathode-Digit 2
3	Cathode-Digit 3
4	Cathode-Digit 4
5	Cathode-Digit 5
6	Anode-Segment e
7	Cathode-Digit 6
8	Anode-Segment d
9	Cathode-Digit 7
10	Anode-Segment a
11	Cathode-Digit 8
12	Anode-Segment DP
13	Cathode-Digit 9
14	Anode-Segment c
15	Cathode-Digit 10
16	Anode-Segment g
17	Cathode-Digit 11
18	Anode-Segment b
19	Cathode-Digit 12
20	Anode-Segment f
21	Cathode-Digit 13
22	Cathode-Digit 14
23	Cathode-Digit 15
24	Cathode-Digit 16

Package Dimensions

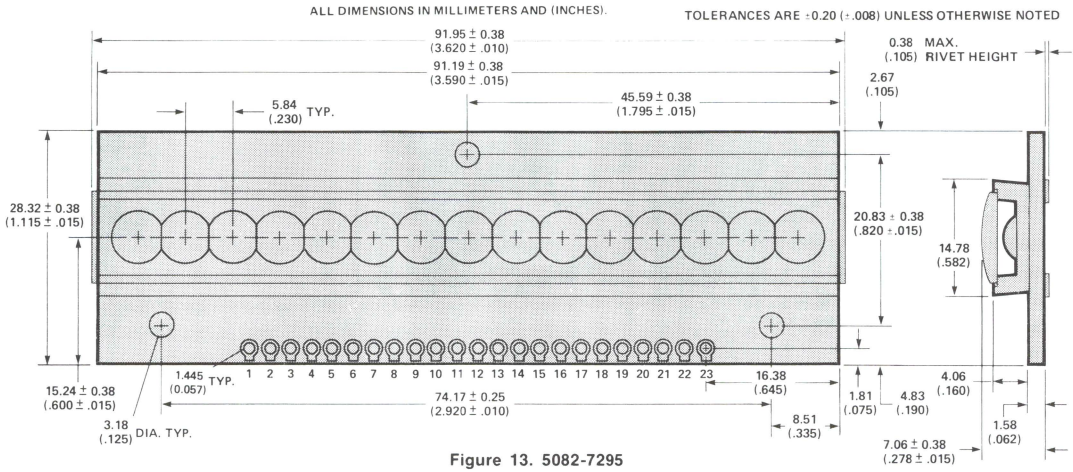
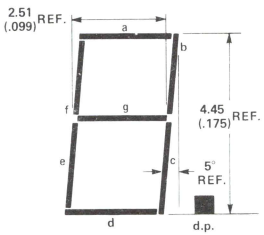


Figure 13. 5082-7295

Magnified Character Font Description

DEVICE
5082-7295



ALL DIMENSIONS IN MILLIMETERS AND (INCHES).

Figure 14.

Device Pin Description

Pin No.	5082-7295 Function
1	Cathode Digit 1
2	Cathode Digit 2
3	Cathode Digit 3
4	Cathode Digit 4
5	Anode Segment dp
6	Cathode Digit 5
7	Anode Segment c
8	Cathode Digit 6
9	Anode Segment e
10	Cathode Digit 7
11	Anode Segment a
12	Cathode Digit 8
13	Anode Segment g
14	Cathode Digit 9
15	Anode Segment d
16	Cathode Digit 10
17	Anode Segment f
18	Cathode Digit 11
19	Anode Segment b
20	Cathode Digit 12
21	Cathode Digit 13
22	Cathode Digit 14
23	Cathode Digit 15

Hermetic Displays

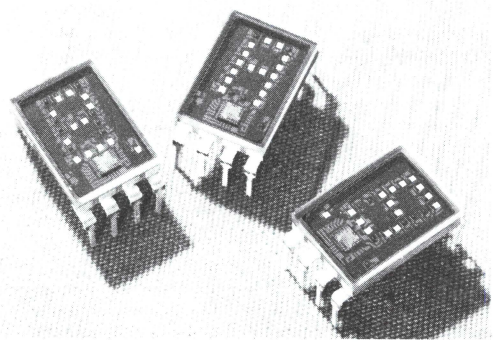
HEWLETT PACKARD

JAN QUALIFIED, HERMETIC, NUMERIC AND HEXADECIMAL DISPLAYS FOR HIGH RELIABILITY APPLICATIONS

4N51 / 4N51TXV / M87157/00101ACX
4N52 / 4N52TXV / M87157/00102ACX
4N53 / 4N53TXV / M87157/00103ACX
4N54 / 4N54TXV / M87157/00104ACX

Features

- **MILITARY QUALIFIED LISTED ON MIL-D-87157 QPL**
- **TRUE HERMETIC PACKAGE**
- **TXV VERSION AVAILABLE**
- **THREE CHARACTER OPTIONS Numeric, Hexadecimal, Over Range**
- **4 x 7 DOT MATRIX CHARACTER**
- **PERFORMANCE GUARANTEED OVER TEMPERATURE**
- **HIGH TEMPERATURE STABILIZED**
- **GOLD PLATED LEADS**
- **MEMORY LATCH/DECODER/DRIVER TTL Compatible**
- **CATEGORIZED FOR LUMINOUS INTENSITY**



Description

These standard red solid state displays have a 7.4 mm (0.29 inch) dot matrix character and an on-board IC with data memory latch/decoder and LED drivers in a glass/ceramic package. These devices utilize a solder glass frit seal and conform to the hermeticity requirements of MIL-D-87157, the general specification for LED displays. These 4N5X series displays are designed for use in military and aerospace applications.

These military qualified displays are designated as M87157/00101ACX through -/00104ACX in the MIL-D-87157 Qualified Parts List (QPL). The letter designations at the end of the part numbers are defined as follows: "A" signifies MIL-D-87157 Quality Level A, "C" signifies gold plated leads, "X" signifies the luminous intensity category.

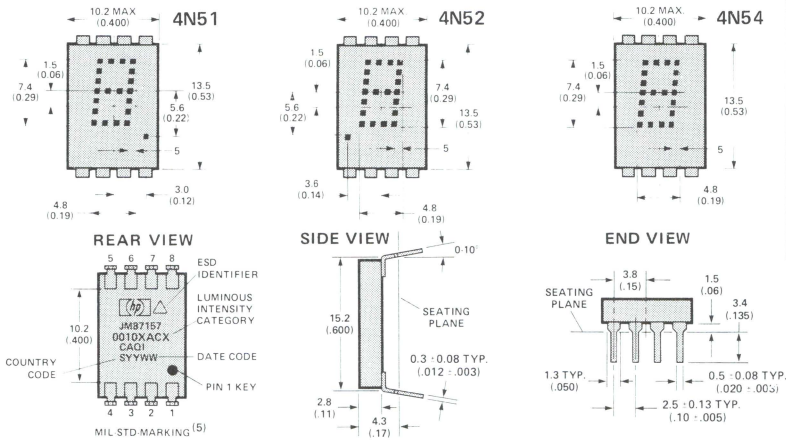
The 4N51 numeric display decodes positive 8421 BCD logic inputs into characters 0-9, a "—" sign, a test pattern, and four blanks in the invalid BCD states. The unit employs a right-hand decimal point.

The 4N52 is the same as the 4N51 except that the decimal point is located on the left-hand side of the digit.

The 4N54 hexadecimal display decodes positive 8421 logic inputs into 16 states, 0-9 and A-F. In place of the decimal point an input is provided for blanking the display (all LED's off), without losing the contents of the memory.

The 4N53 is a "±1." overrange display, including a right-hand decimal point.

Package Dimensions*



PIN	FUNCTION	
	4N51 4N52 NUMERIC	4N54 HEXA-DECIMAL
1	Input 2	Input 2
2	Input 4	Input 4
3	Input 8	Input 8
4	Decimal point	Blanking control
5	Latch enable	Latch enable
6	Ground	Ground
7	V_{CC}	V_{CC}
8	Input 1	Input 1

NOTES:
1. Dimensions in millimetres and (inches).
2. Unless otherwise specified, the tolerance on all dimensions is ±.38mm (±.015")
3. Digit center line is ±.25mm (±.01") from package center line.
4. Lead material is gold plated
5. See over range package drawing for HP standard marking.

*JEDEC Registered Data.

Absolute Maximum Ratings*

Description	Symbol	Min.	Max.	Unit
Storage temperature, ambient	T_S	−65	+125	°C
Operating temperature, ambient [1,2]	T_A	−55	+100	°C
Supply voltage [3]	V_{CC}	−0.5	+7.0	V
Voltage applied to input logic, dp and enable pins	V_I, V_{DP}, V_E	−0.5	V_{CC}	V
Voltage applied to blanking input [7]	V_B	−0.5	V_{CC}	V
Maximum solder temperature at 1.59mm (.062 inch) below seating plane; t ⩽ 5 seconds			260	°C

Recommended Operating Conditions*

Description	Symbol	Min.	Nom.	Max.	Unit
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Operating temperature, ambient [1,2]	T_A	−55		+100	°C
Enable Pulse Width	t_W	100			nsec
Time data must be held before positive transition of enable line	t_{SETUP}	50			nsec
Time data must be held after positive transition of enable line	t_{HOLD}	50			nsec
Enable pulse rise time	t_{TLH}			200	nsec

Electrical/Optical Characteristics* (T_A = −55°C to +100°C, unless otherwise specified)

Description	Symbol	Test Conditions	Min.	Typ. [4]	Max.	Unit
Supply Current	I_{CC}	V_{CC} = 5.5 V (Characters		112	170	mA
Power dissipation	P_T	"5." or "B")		560	935	mW
Luminous intensity per LED (Digit average) [5,6]	I_v	V_{CC}=5.0V, T_A=25°C	40	85		μcd
Logic low-level input voltage	V_{IL}	V_{CC}=4.5V			0.8	V
Logic high-level input voltage	V_{IH}		2.0			V
Enable low-voltage; data being entered	V_{EL}				0.8	V
Enable high-voltage; data not being entered	V_{EH}		2.0			V
Blanking low-voltage; display not blanked [7]	V_{BL}				0.8	V
Blanking high-voltage; display blanked [7]	V_{BH}		3.5			V
Blanking low-level input current [7]	I_{BL}	V_{CC}=5.5V, V_{BL}=0.8V			50	μA
Blanking high-level input current [7]	I_{BH}	V_{CC}=5.5V, V_{BH}=4.5V			1.0	mA
Logic low-level input current	I_{IL}	V_{CC}=5.5V, V_{IL}=0.4V			−1.6	mA
Logic high-level input current	I_{IH}	V_{CC}=5.5V, V_{IH}=2.4V			+100	μA
Enable low-level input current	I_{EL}	V_{CC}=5.5V, V_{EL}=0.4V			−1.6	mA
Enable high-level input current	I_{EH}	V_{CC}=5.5V, V_{EH}=2.4V			+130	μA
Peak wavelength	λ_{PEAK}	T_A=25°C		655		nm
Dominant Wavelength [8]	λ_d	T_A=25°C		640		nm
Weight**				1.0		gm
Leak Rate					$5x10^{-8}$	cc/sec

Notes: 1. Nominal thermal resistance of a display mounted in a socket which is soldered into a printed circuit board: Θ_{JA}=50°C/W; Θ_{JC}=15°C/W. 2. Θ_{CA} of a mounted display should not exceed 35°C/W for operation up to T_A=+100°C. 3. Voltage values are with respect to device ground, pin 6. 4. All typical values at V_{CC}=5.0 Volts, T_A=25°C. 5. These displays are categorized for luminous intensity with the intensity category designated by a letter located on the back of the display contiguous with the Hewlett-Packard logo marking. 6. The luminous intensity at a specific ambient temperature, $I_V(T_A)$, may be calculated from this relationship: $I_V(T_A)=I_{V(25°C)}(.985)^{[T_A-25°C]}$ 7. Applies only to 4N54. 8. The dominant wavelength, λ_d, is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device.

*JEDEC Registered Data. **Non Registered Data.

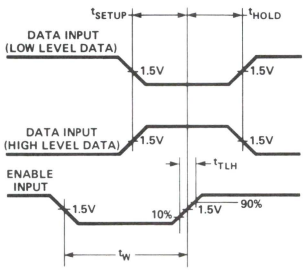


Figure 1. Timing Diagram of 4N51-4N54 Series Logic.

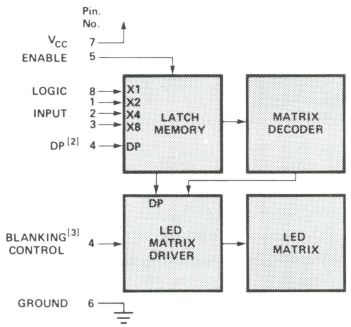


Figure 2. Block Diagram of 4N51-4N54 Series Logic.

TRUTH TABLE					
BCD DATA [1]				4N51 AND 4N52	4N54
X_8	X_4	X_2	X_1		
L	L	L	L	0	0
L	L	L	H	1	1
L	L	H	L	2	2
L	L	H	H	3	3
L	H	L	L	4	4
L	H	L	H	5	5
L	H	H	L	6	6
L	H	H	H	7	7
H	L	L	L	8	8
H	L	L	H	9	9
H	L	H	L	-	A
H	L	H	H	(BLANK)	b
H	H	L	L	(BLANK)	C
H	H	L	H	....	d
H	H	H	L	(BLANK)	E
H	H	H	H	(BLANK)	F
DECIMAL PT. [2]			ON		V_{DP} = L
			OFF		V_{DP} = H
ENABLE [1]			LOAD DATA		V_E = L
			LATCH DATA		V_E = H
BLANKING [3]			DISPLAY-ON		V_B = L
			DISPLAY-OFF		V_B = H

Notes:

1. H = Logic High; L = Logic Low. With the enable input at logic high changes in BCD input logic levels or D.P. input have no effect upon display memory, displayed character, or D.P.
2. The decimal point input, DP, pertains only to the 4N51 and 4N52 displays.
3. The blanking control input, B, pertains only to the 4N54 hexadecimal display. Blanking input has no effect upon display memory.

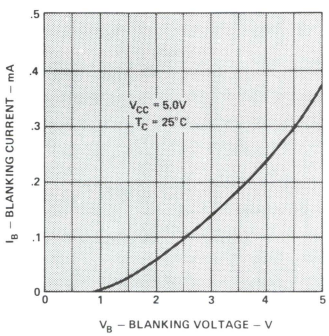


Figure 3. Typical Blanking Control Current vs. Voltage for 4N54.

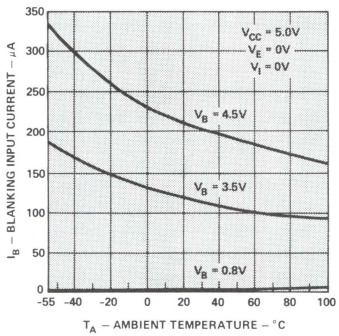


Figure 4. Typical Blanking Control Input Current vs. Ambient Temperature for 4N54.

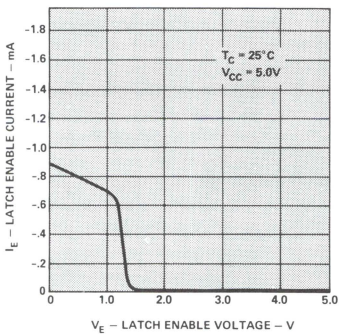


Figure 5. Typical Latch Enable Input Current vs. Voltage.

*JEDEC Registered Data.

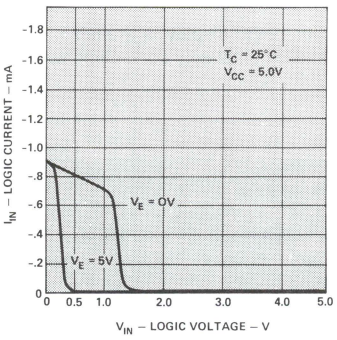


Figure 6. Typical Logic and Decimal Point Input Current vs. Voltage.

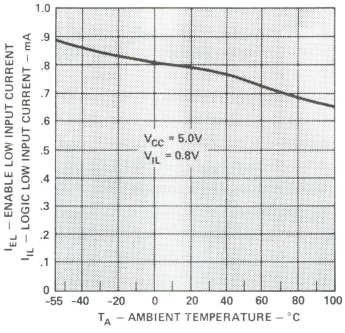


Figure 7. Typical Logic and Enable Low Input Current vs. Ambient Temperature.

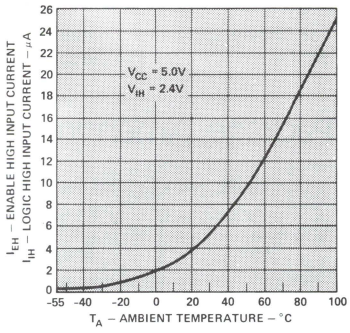


Figure 8. Typical Logic and Enable High Input Current vs. Ambient Temperature.

Operational Considerations

ELECTRICAL

The 4N51-4N54 series devices use a modified 4 x 7 dot matrix of light emitting diodes (LED's) to display decimal/hexadecimal numeric information. The LED's are driven by constant current drivers. BCD information is accepted by the display memory when the enable line is at logic low and the data is latched when the enable is at logic high. To avoid the latching of erroneous information, the enable pulse rise time should not exceed 200 nanoseconds. Using the enable pulse width and data setup and hold times listed in the Recommended Operating Conditions allows data to be clocked into an array of displays at a 6.7MHz rate.

The blanking control input on the 4N54 display blanks (turns off) the displayed hexadecimal information without disturbing the contents of display memory. The display is blanked at a minimum threshold level of 3.5 volts. This may be easily achieved by using an open collector TTL gate and a pull-up resistor. For example, (1/6) 7416 hexinverter buffer/driver and a 120 ohm pull-up resistor will provide sufficient drive to blank eight displays. The size of the blanking pull-up resistor may be calculated from the following formula, where N is the number of digits:

$$R_{blank} = (V_{CC} - 3.5V)/[N\ (1.0mA)]$$

The decimal point input is active low true and this data is latched into the display memory in the same fashion as the BCD data. The decimal point LED is driven by the on-board IC.

The ESD susceptibility of the IC devices is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263.

MECHANICAL

4N51-4N54 series displays are hermetically tested for use in environments which require a high reliability device. These displays are designed and tested to meet a helium leak rate of 5 x 10^{-8} CC/SEC and a fluorocarbon gross leak bubble test.

These displays may be mounted by soldering directly to a printed circuit board or inserted into a socket. The lead-to-lead pin spacing is 2.54mm (0.100 inch) and the lead row spacing is 15.24mm (0.600 inch). These displays may be end stacked with 2.54mm (0.100 inch) spacing between outside pins of adjacent displays. Sockets such as Augat 324-AG2D (3 digits) or Augat 508-AG8D (one digit, right angle mounting) may be used.

The primary thermal path for power dissipation is through the device leads. Therefore, to insure reliable operation up to an ambient temperature of +100° C, it is important to maintain a case-to-ambient thermal resistance of less than 35° C/watt as measured on top of display pin 3.

Post solder cleaning may be accomplished using water, Freon/alcohol mixtures formulated for vapor cleaning processing (up to 2 minutes in vapors at boiling) or Freon/alcohol mixtures formulated for room temperature cleaning. Suggested solvents: Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15.

PRECONDITIONING

4N51-4N54 series displays are 100% preconditioned by 24 hour storage at 125° C.

CONTRAST ENHANCEMENT

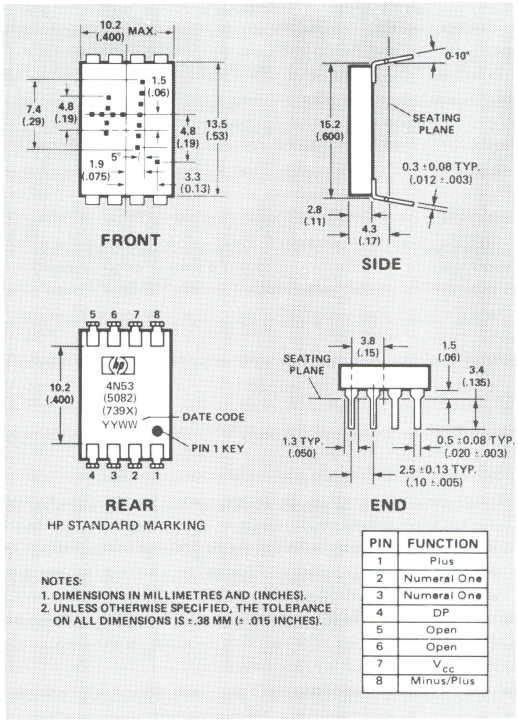
The 4N51-4N54 displays have been designed to provide the maximum posible ON/OFF contrast when placed behind an appropriate contrast enhancement filter. Some suggested filters are Panelgraphic Ruby Red 60 and Dark Red 63, SGL Homalite H100-1605, 3M Light Control Film and Polaroid HRCP Red Circular Polarizing Filter. For further information see Hewlett-Packard Application Note 1015.

*JEDEC Registered Data.

Solid State Over Range Display

For display applications requiring a ±, 1, or decimal point designation, the 4N53 over range display is available. This display module comes in the same package as the 4N51-4N54 series numeric display and is completely compatible with it.

Package Dimensions*



PIN	FUNCTION
1	Plus
2	Numeral One
3	Numeral One
4	DP
5	Open
6	Open
7	V_{CC}
8	Minus/Plus

NOTES:
1. DIMENSIONS IN MILLIMETRES AND (INCHES).
2. UNLESS OTHERWISE SPECIFIED, THE TOLERANCE ON ALL DIMENSIONS IS ±.38 MM (± .015 INCHES).

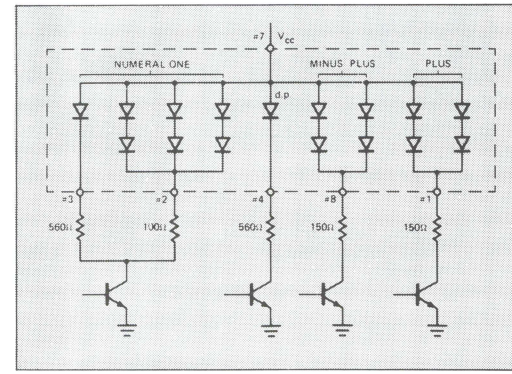


Figure 9. Typical Driving Circuit.

TRUTH TABLE

CHARACTER	PIN			
	1	2,3	4	8
+	H	X	X	H
–	L	X	X	H
1	X	H	X	X
Decimal Point	X	X	H	X
Blank	L	L	L	L

NOTES: L: Line switching transistor in Figure 9 cutoff.
H: Line switching transistor in Figure 9 saturated.
X: 'Don't care'

Electrical/Optical Characteristics*

4N53 (T_A = –55°C to +100°C, Unless Otherwise Specified)

DESCRIPTION	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Forward Voltage per LED	V_F	I_F = 10 mA		1.6	2.0	V
Power dissipation	P_T	I_F = 10 mA all diodes lit		280	320	mW
Luminous Intensity per LED (digit average)	I_v	I_F = 6 mA T_C = 25°C	40	85		µcd
Peak wavelength	λ_{peak}	T_C = 25°C		655		nm
Dominant Wavelength	λ_d	T_C = 25°C		640		nm
Weight * *				1.0		gm

Recommended Operating Conditions*

	SYMBOL	MIN	NOM	MAX	UNIT
LED supply voltage	V_{CC}	4.5	5.0	5.5	V
Forward current, each LED	I_F		5.0	10	mA

NOTE:
LED current must be externally limited. Refer to Figure 9 for recommended resistor values.

*JEDEC Registered Data. **Non Registered Data.

Absolute Maximum Ratings*

DESCRIPTION	SYMBOL	MIN.	MAX.	UNIT
Storage temperature, ambient	T_S	-65	+125	°C
Operating temperature, ambient	T_A	-55	+100	°C
Forward current, each LED	I_F		10	mA
Reverse voltage, each LED	V_R		4	V

High Reliability Testing

Two standard reliability testing programs are available. The military program provides QPL parts that comply to MIL-D-87157 Quality Level A, per Tables I, II, IIIa, and IVa. A second program is an HP modification to the full conformance program and offers the 100% screening portion of Level A, Table I, and Group A, Table II. In addition, a MIL-D-87157 Level B equivalent testing program is available upon request.

PART MARKING SYSTEM

Standard Product	With Table I and II	With Tables I, II, IIIa and IVa
PREFERRED PART NUMBER SYSTEM		
4N51	4N51TXV	M87157/00101ACX
4N52	4N52TXV	M87157/00102ACX
4N54	4N54TXV	M87157/00103ACX
4N53	4N53TXV	M87157/00104ACX

100% Screening

TABLE I.
QUALITY LEVEL A OF MIL-D-87157

Test Screen	MIL-STD-750 Method	Conditions
1. Precap Visual	2072	Interpreted by HP Procedure 5956-7572-52
2. High Temperature Storage	1032	T_A = 125°C, Time = 24 hours
3. Temperature Cycling	1051	Condition B, 10 Cycles, 15 Min. Dwell
4. Constant Acceleration	2006	10,000 G's at Y_1 orientation
5. Fine Leak	1071	Condition H
6. Gross Leak	1071	Condition C
7. Interim Electrical/Optical Tests[2]	—	I_V, I_{CC}, I_{BL}, I_{BH}, I_{EL}, I_{EH}, I_{IL}, and I_{IH} T_A = 25°C
8. Burn-In[1, 3]	1015	Condition B at V_{CC} = 5V and cycle through logic at 1 character per second. T_A = 100°C, t = 160 hours
9. Final Electrical Test[2]	—	Same as Step 7
10. Delta Determinations	—	ΔI_V = -20%, ΔI_{CC} = ± 10 mA, ΔI_{IH} = ±10μA and ΔI_{EH} = ±13 μA
11. External Visual[1]	2009	

Notes:
1. MIL-STD-883 Test Method applies.
2. Limits and conditions are per the electrical/optical characteristics.
3. Burn-in for the over range display shall use Condition B at a nominal I_F = 8 mA per LED, with all LEDs illuminated for t = 160 hours minimum.

TABLE II
GROUP A ELECTRICAL TESTS — MIL-D-87157

Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25°C[1]	I_V, I_{CC}, I_{BL}, I_{BH}, I_{EL}, I_{EH}, I_{IL}, and I_{IH} and visual function, T_A = 25°C	5
Subgroup 2 DC Electrical Tests at High Temperature[1]	Same as Subgroup 1, except delete I_V and visual function. T_A = +100°C	7
Subgroup 3 DC Electrical Tests at Low Temperature[1]	Same as Subgroup 1, except delete I_V and visual function. T_A = -55°C	7
Subgroup 4, 5, and 6 not applicable		
Subgroup 7 Optical and Functional Tests at 25°C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883, Method 2009	7

1. Limits and conditions are per the electrical/optical characteristics.

TABLE IIIa
GROUP B, CLASS A AND B OF MIL-D-87157

Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Resistance to Solvents	1022		4 Devices/ 0 Failures
Internal Visual and Design Verification[1]	2075[7]		1 Device/ 0 Failures
Subgroup 2[2,3]			
Solderability	2026	T_A = 245° C for 5 seconds	LTPD = 15
Subgroup 3			
Thermal Shock (Temp. Cycle)	1051	Condition B1, 15 Min. Dwell	LTPD = 15
Moisture Resistance[4]	1021		
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints[5]	—	I_V, I_{CC}, I_{BL}, I_{BH}, I_{EL}, I_{EH}, I_{IL}, I_{IH} and visual function. T_A = 25° C	
Subgroup 4			
Operating Life Test (340 hrs.)[6]	1027	T_A = +100° C at V_{CC} = 5.0V and cycling through logic at 1 character per second.	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3.	
Subgroup 5			
Non-operating (Storage) Life Test (340 hrs.)	1032	T_A = +125° C	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	

Notes:

1. Visual inspection performed through the display window.
2. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
3. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
4. Initial conditioning is a 15° inward bend, one cycle.
5. Limits and conditions are per the electrical/optical characteristics.
6. Burn-in for the over range display shall use Condition B at a nominal I_F = 8 mA per LED, with all LEDs illuminated for t = 160 hours minimum.
7. Equivalent to MIL-STD-883, Method 2014.

TABLE IVa
GROUP C, CLASS A AND B OF MIL-D-87157

Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Physical Dimensions	2066		2 Devices/ 0 Failures
Subgroup 2[2,7,9]			LTPD = 15
Lead Integrity	2004	Condition B2	
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G, Time = 0.5 ms, 5 blows in each orientation X_1, Y_1, Z_1	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G at Y_1 orientation	
External Visual[4]	1010 or 1011		
Electrical/Optical Endpoints[8]	—	I_V, I_{CC}, I_{BL}, I_{BH}, I_{EL}, I_{EH}, I_{IL}, I_{IH} and visual Function, $T_A = 25°C$	
Subgroup 4[1,3]			
Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		
Subgroup 5			
Bond Strength[5]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			$\lambda = 10$
Operating Life Test[6]	1026	$T_A = +100°C$	
Electrical/Optical Endpoints[8]	—	Same as Subgroup 3	

1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. If a given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1000 hours in order to satisfy the Group C Life Test requirements. In such cases, either the 340 hour endpoint measurements shall be made a basis for Group B lot acceptance or the 1000 hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.
7. MIL-STD-883 test method applies.
8. Limits and conditions are per the electrical/optical characteristics.
9. Initial conditioning is a 15° inward bend, three cycles.

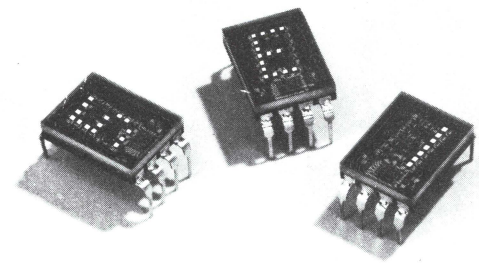
HEWLETT PACKARD

HERMETIC, NUMERIC AND HEXADECIMAL DISPLAYS FOR MILITARY APPLICATIONS

HIGH EFFICIENCY RED	
Low Power	HDSP-078X/078XTXV/078XTXVB
High Brightness	HDSP-079X/079XTXV/079XTXVB
YELLOW	HDSP-088X/088XTXV/088XTXVB
High Performance GREEN	HDSP-098X/098XTXV/098XTXVB

Features

- **CONFORM TO MIL-D-87157, QUALITY LEVEL A TEST TABLES**
- **TRUE HERMETIC PACKAGE FOR HIGH EFFICIENCY RED AND YELLOW[1]**
- **TXV AND TXVB VERSIONS AVAILABLE**
- **THREE CHARACTER OPTIONS**
  Numeric, Hexadecimal, Over Range
- **THREE COLORS**
  High Efficiency Red, Yellow,
  High Performance Green
- **4 x 7 DOT MATRIX CHARACTER**
- **HIGH EFFICIENCY RED, YELLOW, AND HIGH PERFORMANCE GREEN**
- **TWO HIGH EFFICIENCY RED OPTIONS**
  Low Power, High Brightness
- **PERFORMANCE GUARANTEED OVER TEMPERATURE**
- **HIGH TEMPERATURE STABILIZED**
- **GOLD PLATED LEADS**
- **MEMORY LATCH/DECODER/DRIVER**
  TTL Compatible
- **CATEGORIZED FOR LUMINOUS INTENSITY**



Description

These solid state displays have a 7.4 mm (0.29 inch) dot matrix character and an onboard IC with data memory latch/decoder and LED drivers in a glass/ceramic package.

The hermetic HDSP-078X,-079X/-088X displays utilize a solder glass frit seal. The HDSP-098X displays utilize an epoxy glass-to-ceramic seal. All packages conform to the hermeticity requirements of MIL-D-87157, the general specification for LED displays. These displays are designed for use in military and aerospace applications.

The numeric devices decode positive BCD logic into characters "0-9", a "—" sign, decimal point, and a test pattern. The hexadecimal devices decode positive BCD logic into 16 characters, "0-9, A-F". An input is provided on the hexadecimal devices to blank the display (all LEDs off) without losing the contents of the memory.

The over range device displays "±1" and right hand decimal point and is typically driven via external switching transistors.

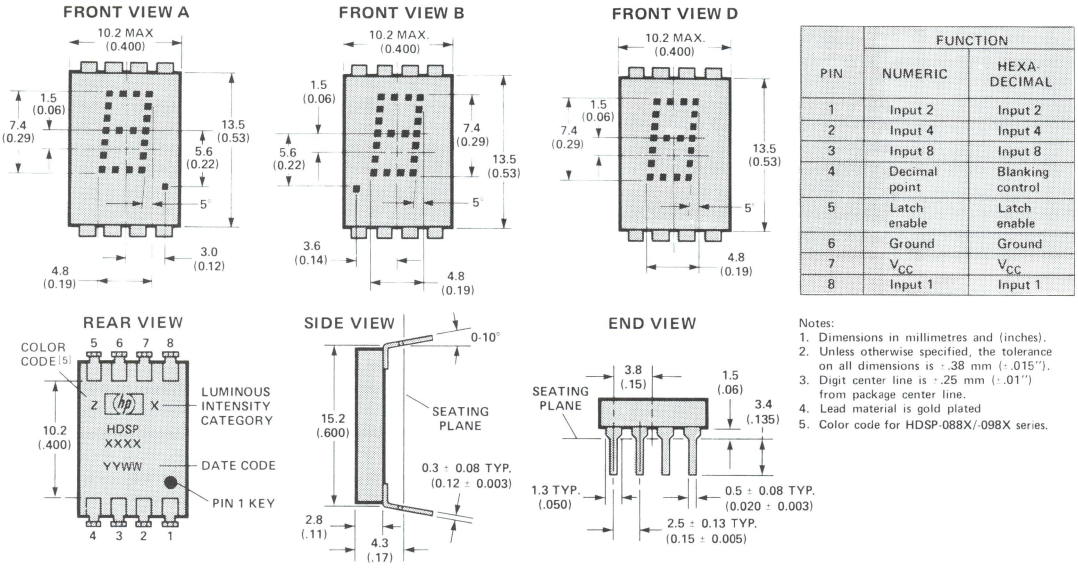
Note:

1. The HDSP-098X high performance green displays are epoxy sealed and conform to MIL-D-87157 hermeticity requirements.

Devices

Part Number HDSP-	Color	Description	Front View
0781/0781TXV/0781TXVB	High-Efficiency Red Low Power	Numeric, Right Hand DP	A
0782/0782TXV/0782TXVB		Numeric, Left Hand DP	B
0783/0783TXV/0783TXVB		Over Range ±1	C
0784/0784TXV/0784TXVB		Hexadecimal	D
0791/0791TXV/0791TXVB	High-Efficiency Red High Brightness	Numeric, Right Hand DP	A
0792/0792TXV/0792TXVB		Numeric, Left Hand DP	B
0783/0783TXV/0783TXVB		Over Range ±1	C
0794/0794TXV/0794TXVB		Hexadecimal	D
0881/0881TXV/0881TXVB	Yellow	Numeric, Right Hand DP	A
0882/0882TXV/0882TXVB		Numeric, Left Hand DP	B
0883/0883TXV/0883TXVB		Over Range ±1	C
0884/0884TXV/0884TXVB		Hexadecimal	D
0981/0981TXV/0981TXVB	High Performance Green	Numeric, Right Hand DP	A
0982/0982TXV/0982TXVB		Numeric, Left Hand DP	B
0983/0983TXV/0983TXVB		Over Range ±1	C
0984/0984TXV/0984TXVB		Hexadecimal	D

Package Dimensions



PIN	FUNCTION	
	NUMERIC	HEXA-DECIMAL
1	Input 2	Input 2
2	Input 4	Input 4
3	Input 8	Input 8
4	Decimal point	Blanking control
5	Latch enable	Latch enable
6	Ground	Ground
7	V_{CC}	V_{CC}
8	Input 1	Input 1

Notes:
1. Dimensions in millimetres and (inches).
2. Unless otherwise specified, the tolerance on all dimensions is ±.38 mm (±.015").
3. Digit center line is ±.25 mm (±.01") from package center line.
4. Lead material is gold plated
5. Color code for HDSP-088X/-098X series.

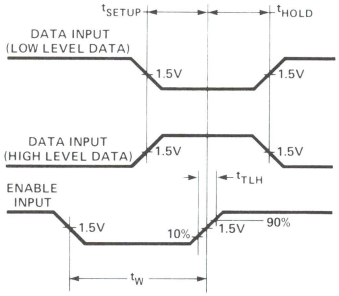


Figure 1. Timing Diagram

TRUTH TABLE					
BCD DATA[1]				NUMERIC	HEXA DECIMAL
X_8	X_4	X_2	X_1		
L	L	L	L	0	0
L	L	L	H	1	1
L	L	H	L	2	2
L	L	H	H	3	3
L	H	L	L	4	4
L	H	L	H	5	5
L	H	H	L	6	6
L	H	H	H	7	7
H	L	L	L	8	8
H	L	L	H	9	9
H	L	H	L		
H	L	H	H	(BLANK)	
H	H	L	L	(BLANK)	
H	H	L	H	-	
H	H	H	L	(BLANK)	
H	H	H	H	(BLANK)	
DECIMAL PT[2]			ON		V_{DP} = L
			OFF		V_{DP} = H
ENABLE[1]			LOAD DATA		V_E = L
			LATCH DATA		V_E = H
BLANKING[3]			DISPLAY ON		V_B = L
			DISPLAY OFF		V_B = H

Notes:
1. H = Logic High; L = Logic Low. With the enable input at logic high changes in BCD input logic levels have no effect upon display memory, displayed character, or DP.
2. The decimal point input, DP, pertains only to the numeric displays.
3. The blanking control input, B, pertains only to the hexadecimal displays. Blanking input has no effect upon display memory.

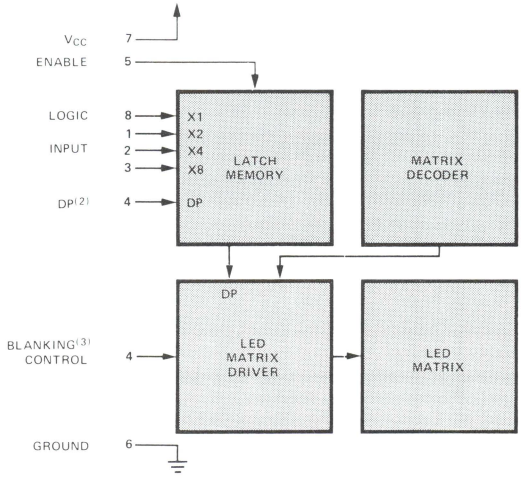


Figure 2. Logic Block Diagram

Absolute Maximum Ratings

Description	Symbol	Min.	Max.	Unit
Storage temperature, ambient	T_S	−65	+125	°C
Operating temperature, ambient [1]	T_A	−55	+100	°C
Supply voltage [2]	V_{CC}	−0.5	+7.0	V
Voltage applied to input logic, dp and enable pins	V_I, V_{DP}, V_E	−0.5	V_{CC}	V
Voltage applied to blanking input [2]	V_B	−0.5	V_{CC}	V
Maximum solder temperature at 1.59mm (.062 inch) below seating plane; t ≤ 5 seconds			260	°C

Recommended Operating Conditions

Description	Symbol	Min.	Nom.	Max.	Unit
Supply Voltage [2]	V_{CC}	4.5	5.0	5.5	V
Operating temperature, ambient [1]	T_A	-55		+100	°C
Enable Pulse Width	t_W	100			nsec
Time data must be held before positive transition of enable line	t_{SETUP}	50			nsec
Time data must be held after positive transition of enable line	t_{HOLD}	50			nsec
Enable pulse rise time	t_{ILH}			1.0	msec

Optical Characteristics at T_A = 25°C, V_{CC} = 5.0V

Device	Description	Symbol	Min.	Typ.	Max.	Unit
HDSP-078X Series	Luminous Intensity per LED (Digit Average) [3,4]	I_V	65	140		μcd
	Peak Wavelength	λ_{PEAK}		635		nm
	Dominant Wavelength [5]	λ_d		626		nm
HDSP-079X Series	Luminous Intensity per LED (Digit Average) [3,4]	I_V	260	620		μcd
	Peak Wavelength	λ_{PEAK}		635		nm
	Dominant Wavelength [5]	λ_d		626		nm
HDSP-088X Series	Luminous Intensity per LED (Digit Average) [3,4]	I_V	215	490		μcd
	Peak Wavelength	λ_{PEAK}		583		nm
	Dominant Wavelength [5,6]	λ_d		585		nm
HDSP-098X Series	Luminous Intensity per LED (Digit Average) [3,4]	I_V	298	1100		μcd
	Peak Wavelength	λ_{PEAK}		568		nm
	Dominant Wavelength	λ_d		574		nm

Notes:

1. The nominal thermal resistance of a display mounted in a socket that is soldered onto a printed circuit board is $R\theta_{JA}$ = 50° C/W/device. The device package thermal resistance is $R\theta_{J-PIN}$ = 15° C/W/device. The thermal resistance device pin-to-ambient through the PC board should not exceed 35° C/W/device for operation at T_A = +100° C.
2. Voltage values are with respect to device ground, pin 6.
3. These displays are categorized for luminous intensity with the intensity category designated by a letter code located on the back of the display package. Case temperature of the device immediately prior to the light measurement is equal to 25° C.

Electrical Characteristics; (T_A = -55° C to +100° C)

Description		Symbol	Test Conditions	Min.	Typ.[7]	Max.	Unit
Supply Current	HDSP-078X Series	I_{CC}	V_{CC} = 5.5 V Characters "5." or "B" displayed		78	105	mA
	HDSP-079X/-088X/ -098X Series				120	175	
Power Dissipation	HDSP-078X Series	P_T	V_{CC} = 5.5 V Characters "5." or "B" displayed		390	573	mW
	HDSP-079X/-088X/ -098X Series				690	963	
Logic, Enable and Blanking Low-Level Input Voltage		V_{IL}	V_{CC} = 4.5 V			0.8	V
Logic, Enable High-Level Input Voltage		V_{IH}		2.0			V
Blanking High Voltage; Display Blanked		V_{BH}		2.3			V
Logic and Enable Low-Level Input Current		I_{IL}	V_{CC} = 5.5 V			-1.6	mA
Blanking Low-Level Input Current		I_{BL}	V_{IL} = 0.4 V			-10	μA
Logic, Enable and Blanking High-Level Input Current		I_{IH}	V_{CC} = 5.5 V V_{IH} = 2.4 V			+40	μA
Weight					1.0		gm
Leak Rate						5×10^{-8}	cc/sec.

Notes:

4. The luminous intensity at a specific operating ambient temperature, $I_V(T_A)$ may be approximated from the following expotential equation: $I_V(T_A = I_V(25° C)\, e^{[k(T_A-25° C)]}$.

Device	K
HDSP-078X Series HDSP-079X Series	-0.0131/° C
HDSP-088X Series	-0.0112/° C
HDSP-098X Series	-0.0104/° C

5. The dominant wavelength, λ_d, is derived from the CIE Chromaticity Diagram and is that single wavelength which defines the color of the device.
6. The HDSP-088X and HDSP-098X series devices are categorized as to dominant wavelength with the category disignated by a number on the back side of the display package.
7. All typical values at V_{CC} = 5.0 V and T_A = 25° C.

Operational Considerations

ELECTRICAL

These devices use a modified 4 x 7 dot matrix of light emitting diodes to display decimal/hexadecimal numeric information. The high efficiency red and yellow displays use GaAsP/GaP LEDs and the high performance green displays use GaP/GaP LEDs. The LEDs are driven by constant current drivers, BCD information is accepted by the display memory when the enable line is at logic low and the data is latched when the enable is at logic high. Using the enable pulse width and data setup and hold times listed in the Recommended Operating Conditions allows data to be clocked into an array of displays at 6.7 MHz rate.

The decimal point input is active low true and this data is latched into the display memory in the same fashion as the BCD data. The decimal point LED is driven by the on-board IC.

The blanking control input on the hexadecimal displays blanks (turns off) the displayed information without disturbing the contents of display memory. The display is blanked at a minimum threshold level of 2.0 volts. When blanked, the display standby power is nominally 250 mW at T_A = 25° C.

The ESD susceptibility of the IC devices is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263.

MECHANICAL

These displays are hermetically sealed for use in environments that require a high reliability device. These displays are designed and tested to meet a helium leak rate of 5 x 10^{-8} cc/sec.

These displays may be mounted by soldering directly to a printed circuit board or insertion into a socket. The lead-to-lead pin spacing is 2.54 mm (0.100 inch) and the lead row spacing is 15.24 mm (0.600 inch). These displays may be end stacked with 2.54 mm (0.100 inch) spacing between outside pins of adjacent displays. Sockets such as Augat 324-AG2D (3 digits) or Augat 508-AG8D (one digit, right angle mounting) may be used.

The primary thermal path for power dissipation is through the device leads. Therefore, to insure reliable operation up to an ambient temperature of +100° C, it is important to maintain a base-to-ambient thermal resistance of less than 35° C watt/device as measured on top of display pin 3.

Post solder cleaning may be accomplished using water, Freon/alcohol mixtures formulated for vapor cleaning processing (up to 2 minutes in vapors at boiling) or Freon/alcohol mixtures formulated for room temperature cleaning. Suggested solvents: Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15.

PRECONDITIONING

These displays are 100% preconditioned by 24 hour storage at 125° C.

CONTRAST ENHANCEMENT

These display devices are designed to provide an optimum ON/OFF contrast when placed behind an appropriate contrast enhancement filter. The following filters are suggested:

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
HDSP-088X Yellow	Panelgraphic Yellow 27 Chequers Amber 107	Polaroid HNCP 37 3M Light Control Film Panelgraphic Gray 10	Polaroid Gray HNCP10 HOYA Yellowish-Orange HLF-608-3Y Marks Gray MCP-0301-8-10
HDSP-078X/-079X HER	Panelgraphic Ruby Red 60 Chequers Red 112	Chequers Grey 105	Polaroid Gray HNCP10 HOYA Reddish-Orange HLF-608-5R Marks Gray MCP-0301-8-10 Marks Reddish-Orange MCP-0201-2-22
HDSP-098X HP Green	Panelgraphic Green 48 Chequers Green 107		Polaroid Gray HNCP10 HOYA Yellow-Green HLF-608-1G Marks Yellow-Green MCP-0101-5-12

Over Range Display

The over range devices display "±1" and decimal point. The character height and package configuration are the same as the numeric and hexadecimal devices. Character selection is obtained via external switching transistors and current limiting resistors.

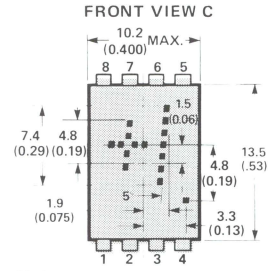
Absolute Maximum Ratings

Description	Symbol	Min.	Max.	Unit
Storage Temperature, Ambient	T_S	-65	+125	°C
Operating Temperature Ambient	T_A	-55	+100	°C
Forward Current, Each LED	I_F		10	mA
Reverse Voltage, Each LED	V_R		5	V

Character	Pin			
	1	2,3	4	8
+	1	X	X	1
—	0	X	X	1
1	X	1	X	X
Decimal Point	X	X	1	X
Blank	0	0	0	0

Notes:
0: Line switching transistor in Figure 7 cutoff.
1: Line switching transistor in Figure 7 saturated.
X: 'don't care'

Package Dimensions



Pin	Function
1	Plus
2	Numeral One
3	Numeral One
4	DP
5	Open
6	Open
7	V_{CC}
8	Minus/Plus

Note:
1. Dimensions in millimetres and (inches).

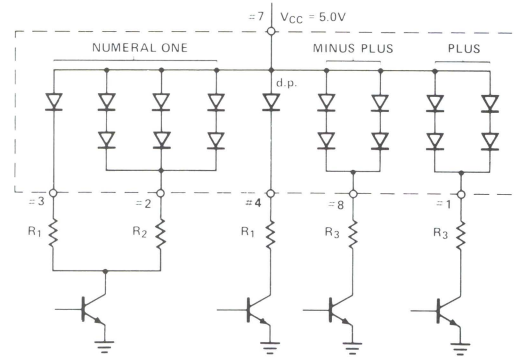


Figure 3. Typical Driving Circuit

Luminous Intensity Per LED

(Digit Average) at $T_A = 25°C$

Device	Test Conditions	Min.	Typ.	Units
HDSP-0783	$I_F = 2.8$ mA	65	140	μcd
	$I_F = 8$ mA		620	μcd
HDSP-0883	$I_F = 8$ mA	215	490	μcd
HDSP-0983	$I_F = 8$ mA	298	1100	μcd

Recommended Operating Conditions $V_{CC} = 5.0V$

Device		Forward Current Per LED, mA	Resistor Value		
			R_1	R_2	R_3
HDSP-0783	Low Power	2.8	1300	200	300
	High Brightness	8	360	47	68
HDSP-0883		8	360	36	56
HDSP-0983		8	360	30	43

Electrical Characteristics ($T_A = -55°C$ to $+100°C$)

Device	Description	Symbol	Test Condition	Min.	Typ.	Max.	Units
HDSP-0783	Power Dissipation (all LEDs Illuminated)	P_T	$I_F = 2.8$ mA		72		mW
			$I_F = 8$ mA		224	282	
	Forward Voltage per LED	V_F	$I_F = 2.8$ mA		1.6		V
			$I_F = 8$ mA		1.75	2.2	
HDSP-0883	Power Dissipation (all LEDs Illuminated)	P_T	$I_F = 8$ mA		237	282	mW
	Forward Voltage per LED	V_F			1.90	2.2	V
HDSP-0983	Power Dissipation (all LEDs illuminated)	P_T	$I_F = 8$ mA		243	282	mW
	Forward Voltage per LED	V_F			1.85	2.2	V

High Reliability Testing

Two standard reliability testing programs are available. The TXVB program is in conformance with Quality Level A Test Tables of MIL-D-87157 for hermetically sealed displays with 100% screening tests. A TXVB product is tested to Tables I, II, IIIa, and IVa. A second program is an HP modification to the full conformance program and offers the 100% screening portion of Level A, Table I, and Group A, Table II.

PART MARKING SYSTEM

Standard Product	With Table I and II	With Tables I, II, IIIa and IVa
HDSP-078X	HDSP-078XTXV	HDSP-078XTXVB
HDSP-079X	HDSP-079XTXV	HDSP-079XTXVB
HDSP-088X	HDSP-088XTXV	HDSP-088XTXVB
HDSP-098X	HDSP-098XTXV	HDSP-098XTXVB

100% Screening

TABLE I. QUALITY LEVEL A OF MIL-D-87157

Test Screen	MIL-STD-750 Method	Conditions
1. Precap Visual	2072	Interpreted by HP Procedure 5956-7572-52
2. High Temperature Storage	1032	$T_A = 125°C$, Time = 24 hours
3. Temperature Cycling	1051	Condition B, 10 Cycles, 15 Min. Dwell
4. Constant Acceleration	2006	10,000 G at Y_1 orientation
5. Fine Leak	1071	Condition H
6. Gross Leak	1071	Condition C
7. Interim Electrical/Optical Tests[2]	—	I_V, I_{CC}, I_{BL}, I_{BH}, I_{EL}, I_{EH}, I_{IL}, and I_{IH} $T_A = 25°C$
8. Burn-In[1, 3]	1015	Condition B at $V_{CC} = 5V$ and cycle through logic at 1 character per second. $T_A = 100°C$, t = 160 hours
9. Final Electrical Test[2]	—	Same as Step 7
10. Delta Determinations	—	$\Delta I_V = -20\%$, $\Delta I_{CC} = \pm 10$ mA, $\Delta I_{IH} = \pm 10\mu A$ and $\Delta I_{EH} = \pm 13\ \mu A$
11. External Visual[1]	2009	

Notes:
1. MIL-STD-883 Test Method applies.
2. Limits and conditions are per the electrical/optical characteristics.
3. Burn-in for the over range display shall use Condition B at a nominal $I_F = 8$ mA per LED, with all LEDs illuminated for T = 160 hours minimum.

TABLE II
GROUP A ELECTRICAL TESTS — MIL-D-87157

Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25° C [1]	I_V, I_{CC}, I_{BL}, I_{BH}, I_{EL}, I_{EH}, I_{IL}, and I_{IH} and visual function, T_A = 25° C	5
Subgroup 2 DC Electrical Tests at High Temperature[1]	Same as Subgroup 1, except delete I_V and visual function. T_A = +100° C	7
Subgroup 3 DC Electrical Tests at Low Temperature[1]	Same as Subgroup 1, except delete I_V and visual function. T_A = -55° C	7
Subgroup 4, 5, and 6 not applicable		
Subgroup 7 Optical and Functional Tests at 25° C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883, Method 2009	7

Notes:
1. Limits and conditions are per the electrical/optical characteristics.

TABLE IIIa
GROUP B, CLASS A AND B OF MIL-D-87157

Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/ 0 Failures
Internal Visual and Design Verification[1]	2075[7]		1 Device/ 0 Failures
Subgroup 2[2,3] Solderability	2026	T_A = 245° C for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp. Cycle)	1051	Condition B1, 15 min. Dwell	LTPD = 15
Moisture Resistance[4]	1021		
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints[5]	—	I_V, I_{CC}, I_{BL}, I_{BH}, I_{EL}, I_{EH}, I_{IL}, I_{IH} and visual function. T_A = 25° C	
Subgroup 4 Operating Life Test (340 hrs.)[6]	1027	T_A = +100° C at V_{CC} = 5.0V and cycling through logic at 1 character per second.	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3.	
Subgroup 5 Non-operating (Storage) Life Test (340 hrs.)	1032	T_A = +125° C	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	

Notes:
1. Visual inspection performed through the display window.
2. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
3. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
4. Initial conditioning is a 15° inward bend, one cycle.
5. Limits and conditions are per the electrical/optical characteristics.
6. Burn-in for the over range display shall use Condition B at a nominal $I_F \pm 8$ mA with '+' illuminated for t = 160 hours.
7. Equivalent to MIL-STD-883, Method 2014.

TABLE IVa
GROUP C, CLASS A AND B OF MIL-D-87157

Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Physical Dimensions	2066		2 Devices/ 0 Failures
Subgroup 2[2,7,9]			LTPD = 15
Lead Integrity	2004	Condition B2	
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G, Time = 0.5 ms, 5 blows in each orientation X_1, Y_1, Z_1	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G at Y_1 orientation	
External Visual[4]	1010 or 1011		
Electrical/Optical Endpoints[8]	—	I_V, I_{CC}, I_{BL}, I_{BH}, I_{EL}, I_{EH}, I_{IL}, I_{IH} and visual Function, $T_A = 25°C$	
Subgroup 4[1,3]			
Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		
Subgroup 5			
Bond Strength[5]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			$\lambda = 10$
Operating Life Test[6]	1026	$T_A = +100°C$	
Electrical/Optical Endpoints[8]	—	Same as Subgroup 3	

Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. If a given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1000 hours in order to satisfy the Group C Life Test requirements. In such cases, either the 340 hour endpoint measurements shall be made a basis for Group B lot acceptance or the 1000 hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.
7. MIL-STD-883 test method applies.
8. Limits and conditions are per the electrical/optical characteristics.
9. Initial conditioning is a 15° inward bend, 3 cycles.

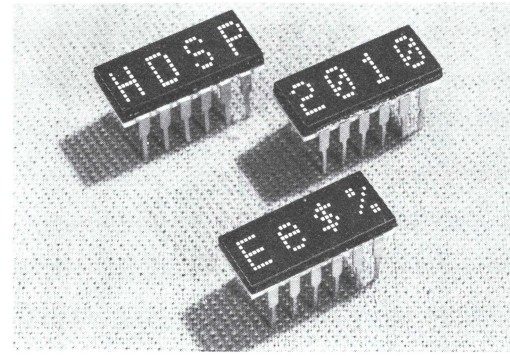
HEWLETT PACKARD

FOUR CHARACTER RED ALPHANUMERIC DISPLAY FOR EXTENDED TEMPERATURE APPLICATIONS

HDSP-2010
HDSP-2010TXV
HDSP-2010TXVB

Features

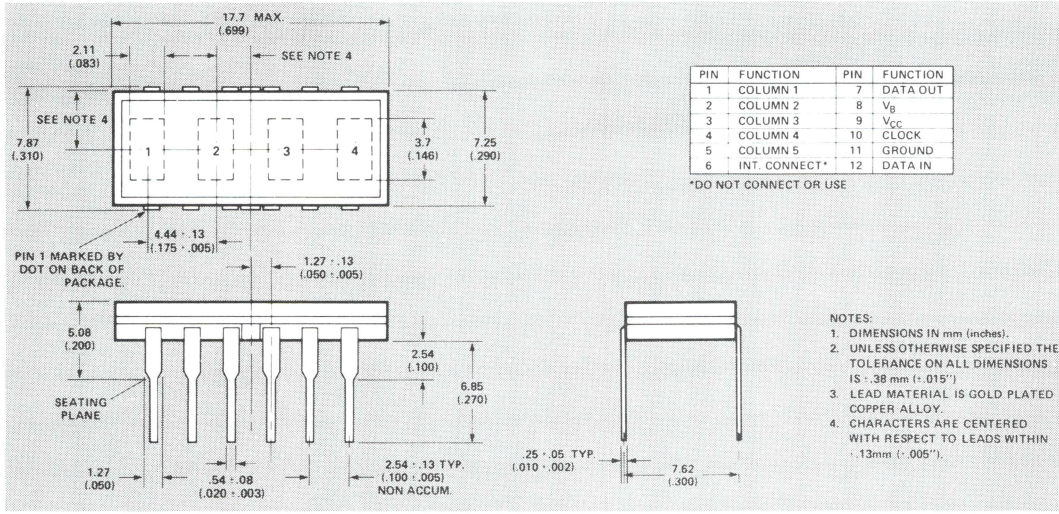
- **OPERATION GUARANTEED TO T_A = -40° C**
- **LEAK RATE GUARANTEED**
- **TXVB VERSION CONFORMS TO MIL-D-87157 QUALITY LEVEL A TEST TABLES**
- **GOLD PLATED LEADS**
- **INTEGRATED SHIFT REGISTERS WITH CONSTANT CURRENT DRIVERS**
- **CERAMIC 7.62mm (.3 in.) DIP Integral Red Glass Contrast Filter**
- **WIDE VIEWING ANGLE**
- **END STACKABLE 4 CHARACTER PACKAGE**
- **PIN ECONOMY 12 Pins for 4 Characters**
- **TTL COMPATIBLE**
- **5 x 7 LED MATRIX DISPLAYS FULL ASCII CODE**
- **RUGGED, LONG OPERATING LIFE**
- **CATEGORIZED FOR LUMINOUS INTENSITY Assures Ease of Package to Package Brightness Matching**



Description

The HDSP-2010 display is designed for use in applications requiring high reliability. The character font is a 3.8mm (0.15 inch) 5 x 7 red LED array for displaying alphanumeric information. The device is available in 4 character clusters and is packaged in a 12-pin dual-in-line type package. An on-board SIPO (serial-in-parallel-out) 7-bit shift register associated with each digit controls constant current LED row drivers. Full character display is achieved by external column strobing. The constant current LED drivers are externally programmable and typically capable of sinking 13.5mA peak per diode. Applications include interactive I/O terminals, avionics, portable telecommunications gear, and hand held equipment requiring alphanumeric displays.

Package Dimensions



PIN	FUNCTION	PIN	FUNCTION
1	COLUMN 1	7	DATA OUT
2	COLUMN 2	8	V_B
3	COLUMN 3	9	V_{CC}
4	COLUMN 4	10	CLOCK
5	COLUMN 5	11	GROUND
6	INT. CONNECT*	12	DATA IN

*DO NOT CONNECT OR USE

NOTES:
1. DIMENSIONS IN mm (inches).
2. UNLESS OTHERWISE SPECIFIED THE TOLERANCE ON ALL DIMENSIONS IS ±.38 mm (±.015").
3. LEAD MATERIAL IS GOLD PLATED COPPER ALLOY.
4. CHARACTERS ARE CENTERED WITH RESPECT TO LEADS WITHIN ±.13mm (±.005").

Absolute Maximum Ratings

Supply Voltage V_{CC} to Ground ..... −0.5V to 6.0V
Inputs, Data Out and V_B ..... −0.5V to V_{CC}
Column Input Voltage, V_{COL} ..... −0.5V to +6.0V
Free Air Operating Temperature Range, T_A[2] ..... −40°C to +85°C
Storage Temperature Range, T_S ..... -55°C to +100°C
Maximum Allowable Power Dissipation at $T_A = 25°C$[1,2,6] ..... 1.29 Watts
Maximum Solder Temperature 1.59mm (.063") Below Seating Plane t<5 secs ..... 260°C

Recommended Operating Conditions

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.75	5.0	5.25	V
Data Out Current, Low State	I_{OL}			1.6	mA
Data Out Current, HighState	I_{OH}			−0.5	mA
Column Input Voltage, Column On	V_{COL}	2.6		3.5	V
Setup Time	t_{setup}	70	45		ns
Hold Time	t_{hold}	30	0		ns
Width of Clock	$t_{w(Clock)}$	75			ns
Clock Frequency	f_{clock}	0		3	MHz
Clock Transition Time	t_{THL}			200	ns
Free Air Operating Temperature Range	T_A	-40		85	°C

Electrical Characteristics Over Operating Temperature Range

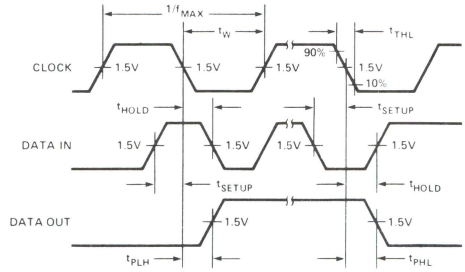
(Unless otherwise specified.)

Description		Symbol	Test Conditions		Min.	Typ.*	Max.	Units
Supply Current		I_{CC}	V_{CC} = 5.25V, V_{CLOCK} = V_{DATA} = 2.4V, All SR Stages = Logical 1	V_B = 0.4V		45	60	mA
				V_B = 2.4V		73	95	mA
Column Current at any Column Input		I_{COL}	V_{CC} = 5.25V, V_{COL} = 3.5V, All SR Stages = Logical 1	V_B = 0.4V			500	μA
Column Current at any Column Input		I_{COL}		V_B = 2.4V		350	435	mA
Peak Luminous Intensity per LED[3,7] (Character Average)		I_{VPEAK}	V_{CC} = 5.0V, V_{COL} = 3.5V, T_i = 25°C[4] V_B = 2.4V		105	200		μcd
V_B, Clock or Data Input Threshold High		V_{IH}	V_{CC} = V_{COL} = 4.75V		2.0			V
V_B, Data Input Threshold Low		V_{IL}					0.8	V
Clock Threshold Low		V_{IL}					0.6	V
Input Current Logical 1	V_B, Clock	I_{IH}	V_{CC} = 5.25V, V_{IH} = 2.4V			20	80	μA
	Data In	I_{IH}				10	40	μA
Input Current Logical 0	V_B, Clock	I_{IL}	V_{CC} = 5.25V, V_{IL} = 0.4V			-500	-800	μA
	Data In	I_{IL}				-250	-400	μA
Data Out Voltage		V_{OH}	V_{CC} = 4.75V, I_{OH} = -0.5mA, V_{COL} = 0V		2.4	3.4		V
		V_{OL}	V_{CC} = 4.75V, I_{OL} = 1.6mA, V_{COL} = 0V			0.2	0.4	V
Power Dissipation Per Package**		P_D	V_{CC} = 5.0V, V_{COL} = 3.5V 17.5% DF, 15 LEDs on per character, V_B = 2.4V			.74		W
Peak Wavelength		λ_{PEAK}				655		nm
Dominant Wavelength[5]		λ_d				640		nm
Thermal Resistance IC Junction-to-Case		$R\theta_{J-C}$				25		°C/W/ Device
Leak Rate							$5x10^{-7}$	cc/s

*All typical values specified at V_{CC} = 5.0V and T_A = 25°C unless otherwise noted.

**Power dissipation per package with 4 characters illuminated.

1. Operation above 85°C ambient is possible provided the following conditions are met. The junction temperature should not exceed 125°C T_J and the case temperature as measured at pin 1 or the back of the display should not exceed 100°C T_C.
2. The device should be derated linearly above 50°C at 16.7 mW/°C. This derating is based on a device mounted in a socket having a thermal resistance from case to ambient at 35° C/W per device. See Figure 2 for power deratings based on a lower thermal resistances.
3. The characters are categorized for Luminous Intensity with the category designated by a letter code on the bottom of the package.
4. T_i refers to the initial case temperature of the device immediately prior to the light measurement.
5. Dominant wavelength λ_d, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
6. Maximum allowable dissipation is derived from V_{CC} = V_B = 5.25 Volts, V_{COL} = 3.5V, 20 LEDs on per character, 20% DF.
7. The luminous stearance of the LED may be calculated using the following relationships:
   L_V (cd/m2) = I_V (Candela/A (Metre)2
   L_V (Footlamberts) = πI_V (Candela)/A (Foot)2
   A = 5.3 x 10^{-8} M^2 = 5.8 x 10^{-7} (Foot)2



Parameter	Condition	Min.	Typ.	Max.	Units
f_{clock} CLOCK Rate				3	MHz
t_{PLH}, t_{PHL} Propagation delay CLOCK to DATA OUT	C_L = 15pF R_L=2.4KΩ			125	ns

Figure 1. Switching Characteristics. (V_{CC} = 5V, T_A = -40°C to +70°C)

Mechanical and Thermal Considerations

The HDSP-2010 is available in a standard 12 lead ceramic-glass dual in-line package. It is designed for plugging into DIP sockets or soldering into PC boards. The packages may be horizontally or vertically stacked for character arrays of any desired size.

The HDSP-2010 can be operated over a wide range of temperature and supply voltages. Power reduction can be achieved by either decreasing V_{COL} or decreasing the average drive current through pulse width modulation of V_B.

The HDSP-2010 display has a glass lens. A front panel contrast filter is desirable in most actual display applications. Some suggested filters are Panel graphic Ruby Red 60, SGL Homalite H100-1605 Red and 3M Light Control Film (louvered filters). OCLI Sungard optically coated glass filters offer superior contrast enhancement.

Post solder cleaning may be accomplished using water, Freon/alcohol mixtures formulated for vapor cleaning processing (up to 2 minutes in vapors at boiling) or Freon/alcohol mixtures formulated for room temperature cleaning. Suggested solvents: Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15.

Electrical Description

The HDSP-2010 display provides on-board storage of decoded column data and constant current sinking row drivers for each of 28 rows in the 4 character display. The device consists of four LED matrices and two integrated circuits that form a 28-bit serial input-parallel output (SIPO) shift register, see Figure 5. Each character is a 5 x 7 diode array arranged with the cathodes of each row connected to one constant current sinking output of the SIPO shift register. The anodes of each column are connected together, with the same column of each of the 4 characters connected together (i.e. column 1 of all four characters are connected to pin 1). Any LED within any character may be addressed by shifting data to the appropriate shift register location and applying a voltage to the appropriate column.

Associated with each shift register location is a constant current sinking LED driver, capable of sinking a nominal 13.5 mA. A logical 1 loaded into a shift register location enables the current source at that location. A voltage applied to the appropriate column input turns on the desired LED.

The display is column strobed on a 1 of 5 basis by loading 7 bits of row data per character for a selected column. The data is shifted through the SIPO shift register, one bit location for each high-to-low transition of the clock. When the HDSP-2010 display is operated with pin 1 in the lower left hand corner, the first bit that is loaded into the SIPO shift register will be the information for row 7 of the right most character. The 28th bit loaded into the SIPO shift register will be the information for row 1 of the left most character. When the 28 bits of row data for column 1 have been loaded into the SIPO shift register, the first column is energized for a time period, T, illuminating column 1 in all four characters. Column 1 is turned off and the process is repeated for columns 2 through 5.

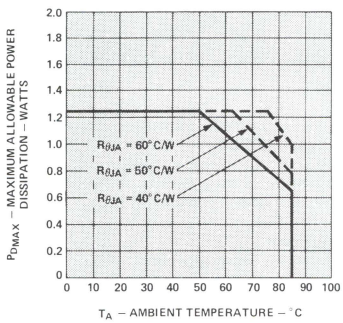


Figure 2. Maximum Allowable Power Dissipation vs. Temperature.

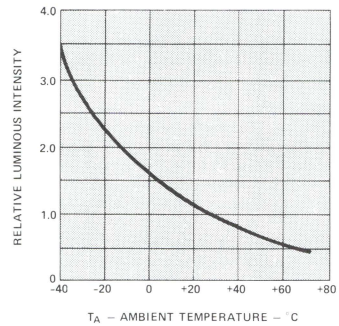


Figure 3. Relative Luminous Intensity vs. Temperature.

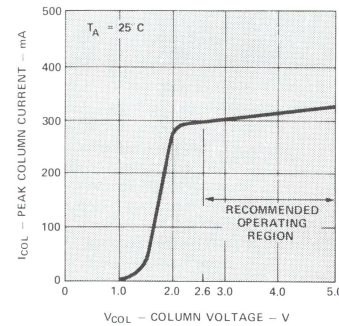


Figure 4. Peak Column Current vs. Column Voltage.

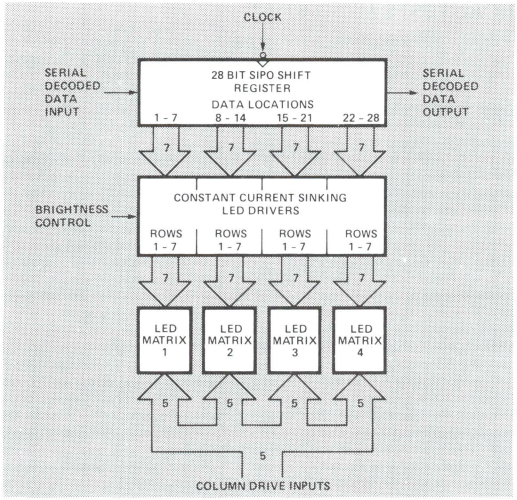


Figure 5. Block Diagram of the HDSP-2010 Display

The time frame allotted per column is $(t + T)$ and the minimum recommended refresh rate for a flicker free display is 100 Hz, so that $(t + T) \leq 2$ ms. If the display is operated at the 3 MHz maximum clock rate, it is possible to maintain $t << T$. For display strings of 24 characters or less, the LED on time DF will be approximately 19.4%. For longer display strings, operation of the display with DF approximately 10% will provide adequate light output for indoor applications.

The 28th stage of the SIPO shift register is connected to the Data Output, which is designed to interface directly to the Data Input of the next HDSP-2010 in the display string.

The V_B input may be used to control the apparent brightness of the display. A logic high applied to the V_B input enables the display to be turned ON, and a logic low blanks the display by disabling the constant current LED drivers. Therefore, the time average luminous intensity of the display can be varied by pulse width modulation of V_B. For application and drive circuit information refer to HP Application Note 1016.

The ESD susceptibility of these IC devices is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263.

High Reliability Testing

Two standard reliability testing programs are available. The TXVB program is in conformance with Quality Level A of MIL-D-87157 for hermetically sealed displays with 100% screening tests. A TXVB product is tested to Tables I, II, IIIa, and IVa. A second program is an HP modification to the full conformance program and offers the 100% screening portion of Level A, Table I, and Group A, Table II.

PART MARKING SYSTEM

Standard Product	With Table I and II	With Tables I, II, IIIa, and IVa
HDSP-2010	HDSP-2010TXV	HDSP-2010TXVB

100% Screening

TABLE I. QUALITY LEVEL A OF MIL-D-87157

Test Screen	MIL-STD-750 Method	Conditions
1. Precap Visual	2072	Interpreted by HP Procedure 5956-7512-52
2. High Temperature Storage	1032	$T_A = 100°C$, Time = 24 hours
3. Temperature Cycling	1051	$T_A = -55°C$ to $+100°C$, 10 cycles, 15 min. dwell
4. Constant Acceleration	2006	10,000 G's at Y_1 orientation
5. Fine Leak	1071	Condition H, Leak Rate $\leq 5 \times 10^{-7}$ cc/s
6. Gross Leak	1071	Condition C, except fluid temperature shall be $+100°C$
7. Interim Electrical/Optical Tests[2]	—	I_{CC} (at $V_B = 0.4V$ and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. $T_A = 25°C$
8. Burn-In[1]	1015	Condition B at $V_{CC} = V_B = 5.25V$, V_{COL} = 3.5V, $T_A = +85°C$ LED ON-Time Duty Factor = 5%, t = 160 hours
9. Final Electrical Test[2]	—	Same as Step 7
10. Delta Determinations	—	$\Delta I_{CC} = \pm 6$ mA, ΔI_{IH} (clock) $= \pm 10\ \mu A$ ΔI_{IH} (Data In) $= \pm 10\ \mu A$ $\Delta I_{OH} = \pm 10\%$ of initial value and $\Delta I_V = -20\%$
11. External Visual[1]	2009	

Notes:
1. MIL-STD-883 Test Method applies.
2. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.

TABLE II. GROUP A ELECTRICAL TESTS MIL-D-87157

Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25° C[1]	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test.	5
Subgroup 2 DC Electrical Tests at High Temperature[1]	Same as Subgroup 1, except delete I_V and visual function. T_A = +85° C	7
Subgroup 3 DC Electrical Tests at Low Temperature[1]	Same as Subgroup 1, except delete I_V and visual function. T_A = -40° C	7
Subgroup 4, 5, and 6 not tested		
Subgroup 7 Optical and Functional Tests at 25° C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883, Method 2009	7

Note:
1. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.

TABLE IIIa. GROUP B, CLASS A AND B OF MIL-D-87157

Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/ 0 Failures
Internal Visual and Design Verification[1]	2075[6]		1 Device/ 0 Failures
Subgroup 2[2,3] Solderability	2026	T_A = 245° C for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp. Cycle)	1051	T_A = -55° C to +100° C 15 min. dwell	LTPD = 15
Moisture Resistance[4]	1021		
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C, except fluid temperature shall be +100° C	
Electrical/Optical Endpoints[5]	—	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25° C	
Subgroup 4 Operating Life Test (340 hrs.)	1027	T_A = +85° C at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, LED ON-Time Duty Factor = 5%	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	
Subgroup 5 Non-operating (Storage) Life Test (340 hrs.)	1032	T_A = +100° C	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	

Notes:
1. Visual inspection is performed through the display window.
2. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
3. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
4. Initial conditioning is a 15° inward bend for one cycle.
5. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
6. Equivalent to MIL-STD-883, Method 2014

TABLE IVa.
GROUP C, CLASS A AND B OF MIL-D-87157

Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1[1]			
Physical Dimensions	2066		2 Devices/ 0 Failures
Subgroup 2[2]			LTPD = 15
Lead Integrity[7, 9]	2004	Condition B2	
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C, except fluid temperature shall be +100° C	
Subgroup 3			
Shock	2016	1500G, Time = 0.5 ms, 5 blows in each orientation X_1, Y_1, Z_1	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G at Y_1 orientation	
External Visual[4]	1010 or 1011		
Electrical/Optical Endpoints[8]	—	I_{CC} (at V_B = 0.4V and 2.4V) I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In) I_{IL} (V_B, Clock and Data In) I_{OH}, I_{OL}, Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25° C.	
Subgroup 4[1,3]			
Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		
Subgroup 5			
Bond Strength[5]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			
Operating Life Test[6]	1026	T_A = +85° C at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V	λ = 10
Electrical/Optical Endpoints[8]	—	Same as Subgroup 3	

1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. If a given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1000 hours in order to satisfy the Group C life test requirements. In such cases, either the 340 hour endpoint measurements shall be made a basis for Group B lot acceptance or the 1000 hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.
7. MIL-STD-883 test method applies.
8. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
9. Initial conditioning is a 15° inward bend for three cycles.

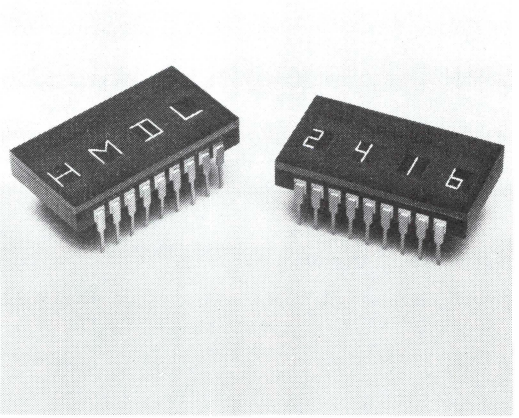
HEWLETT PACKARD

FOUR CHARACTER 3.8mm (0.15 inch) HERMETIC, SMART ALPHANUMERIC DISPLAY

HMDL-2416
HMDL-2416TXV
HMDL-2416TXVB

Features

- **WIDE OPERATING TEMPERATURE RANGE -55° C to +100° C**
- **TRUE HERMETIC PACKAGE**
- **TXVB VERSION CONFORMS TO MIL-D-87157 QUALITY LEVEL A TEST TABLES**
- **CMOS IC FOR LOW POWER CONSUMPTION**
- **SMART ALPHANUMERIC DISPLAY Built-in RAM, ASCII Decoder, and LED Drive Circuitry**
- **VERY FAST ACCESS TIME, 160 ns**
- **EXCELLENT ESD PROTECTION Built-in Protective Diodes**
- **FULL TTL COMPATIBILITY OVER OPERATING TEMPERATURE RANGE**
- **END-STACKABLE**
- **WIDE VIEWING ANGLE**
- **WAVE SOLDERABLE**



Description

The HMDL-2416 is a smart 3.8 mm (0.15") four character, sixteen segment red GaAsP display. It is contained in a hermetic 18 pin dual-in-line, glass sealed ceramic package. The on-board CMOS IC contains memory, ASCII decoder, multiplexing circuitry, and drivers. It has a wide operating temperature range, and is fully TTL compatible, wave solderable, and highly reliable. This display is ideally suited for military and high reliability industrial applications where a rugged, reliable, easy-to-use alphanumeric display is required.

Typical Applications

- **MILITARY EQUIPMENT**
- **AVIONICS**
- **HIGH RELIABILITY INDUSTRIAL EQUIPMENT**

Absolute Maximum Ratings

Supply Voltage, V_{CC} to Ground ..... -0.5 V to 7.0 V

Input Voltage,
Any Pin to Ground ..... -0.5 V to V_{CC} + .5 V

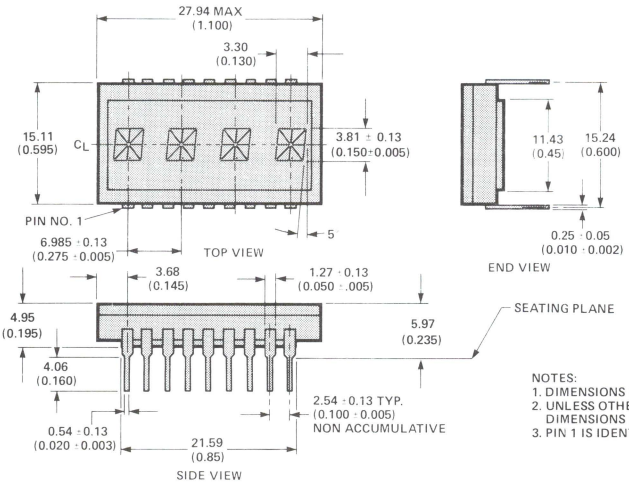
Free Air Operating
Temperature Range, T_A ..... -55° to +100° C

Storage Temperature, T_S ..... -65° to +125° C

Maximum Solder Temperature, 1.59 mm (0.063 in.)
below Seating Plane, t < 5 sec. ..... 260° C

ESD WARNING: The HMDL-2416 is implemented in a standard CMOS process with diode protection of all inputs. The ESD susceptibility of this IC device is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263. Standard precautions for handling CMOS devices should be observed.

Package Dimensions



PIN NO.	FUNCTION	PIN NO.	FUNCTION
1	$\overline{CE}_1$ CHIP ENABLE	10	GND
2	$\overline{CE}_2$ CHIP ENABLE	11	D_0 DATA INPUT
3	$\overline{CLR}$ CLEAR	12	D_1 DATA INPUT
4	$\overline{CUE}$ CURSOR ENABLE	13	D_2 DATA INPUT
5	$\overline{CU}$ CURSOR SELECT	14	D_3 DATA INPUT
6	$\overline{WR}$ WRITE	15	D_6 DATA INPUT
7	A_1 DIGIT SELECT	16	D_5 DATA INPUT
8	A_0 DIGIT SELECT	17	D_4 DATA INPUT
9	V_{CC}	18	$\overline{BL}$ DISPLAY BLANK

NOTES:
1. DIMENSIONS IN mm (INCHES).
2. UNLESS OTHERWISE SPECIFIED THE TOLERANCE ON ALL DIMENSIONS IS ±0.38 mm (0.015").
3. PIN 1 IS IDENTIFIED BY INK DOT ON BOTTOM OF PACKAGE.

Recommended Operating Conditions

Parameter	Symbol	Min.	Nom.	Max.	Units
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Input Voltage High	V_{IH}	2.0			V
Input Voltage Low	V_{IL}			0.8	V

DC Electrical Characteristics Over Operating Temperature Range

TYPICAL VALUES

Parameter	Symbol	Units	-55° C	25° C	+100° C	Test Condition
I_{CC} 4 digits on (10 seg/digit)[1,2]	I_{CC}	mA	120	85	70	V_{CC} = 5.0 V
I_{CC} Cursor[2,3,4]	$I_{CC}(\overline{CU})$	mA	170	125	105	V_{CC} = 5.0 V
I_{CC} Blank	$I_{CC}(\overline{BL})$	mA	1.8	1.5	1.3	V_{CC} = 5.0 V $\overline{BL}$ = 0.8 V
Input Current, Max.	I_{IL}	μA	22	17	12	V_{CC} = 5.0 V V_{IN} = 0.8 V
Thermal Resistance Junction to Case	$R\Theta_{J-C}$	°C/W/ Device		20		

GUARANTEED VALUES

Parameter	Symbol	Units	25° C V_{CC} = 5.0 V	Maximum Over Operating Temperature Range V_{CC} = 5.5 V
I_{CC} 4 digits on (10 seg/digit)[1,2]	I_{CC}	mA	115	167
I_{CC} Cursor[2,3,4]	$I_{CC}(\overline{CU})$	mA	165	225
I_{CC} Blank	$I_{CC}(\overline{BL})$	mA	3.5	8.0
Input Current, Max.	I_{IL}	μA	30	40
Power Dissipation[5]	P_D	mW	575	918
Leak Rate	LR	cc/sec		5×10^{-8}

Notes:
1. "%" illuminated in all four characters.
2. Measured at five seconds.
3. Cursor character is sixteen segments and DP on.
4. Cursor operates continuously over operating temperature range.
5. Power dissipation = $V_{CC} \cdot I_{CC}$ (10 seg.).

AC Timing Characteristics Over Temperature at V_{CC} = 4.5 V [1]

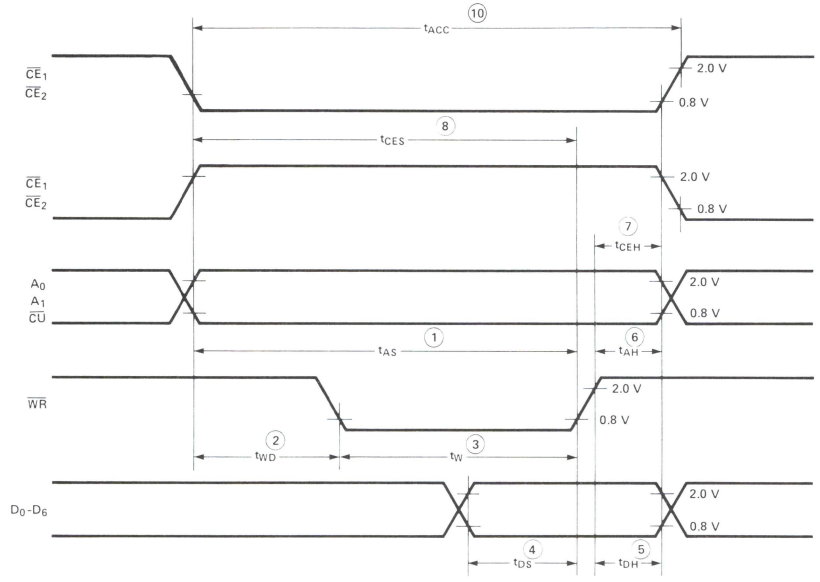
Symbol	Description	-20° C t_{MIN}	25° C t_{MIN}	70° C t_{MIN}	Units
1 t_{AS}	Address Setup Time	90	115	150	ns
2 t_{WD}	Write Delay Time	10	15	20	ns
3 t_W	Write Time	80	100	130	ns
4 t_{DS}	Data Setup Time	40	60	80	ns
5 t_{DH}	Data Hold Time	40	45	50	ns
6 t_{AH}	Address Hold Time	40	45	50	ns
7 t_{CEH}	Chip Enable Hold Time	40	45	50	ns
8 t_{CES}	Chip Enable Setup Time	90	115	150	ns
9 t_{CLR}	Clear Time	2.4	3.5	4.0	ms
10 t_{ACC}	Access Time	130	160	200	ns
	Refresh Rate	420-790	310-630	270-550	Hz

Note: 1. These parameters are guaranteed by design but are not tested.

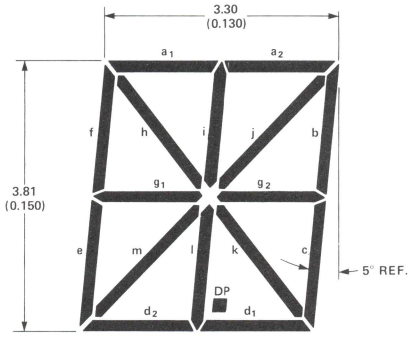
Optical Characteristics

Parameter	Symbol	Test Condition	Min.	Typ.	Units
Peak Luminous Intensity per digit, 8 segments on (character average)	I_V Peak	V_{CC} = 5.0 V "λ" illuminated in all 4 digits (25°C)	0.2	0.6	mcd
Peak Wavelength	λpeak			655	nm
Dominant Wavelength	λ_d			640	nm
Off Axis Viewing Angle				±65	degrees
Digit Size				3.81	mm

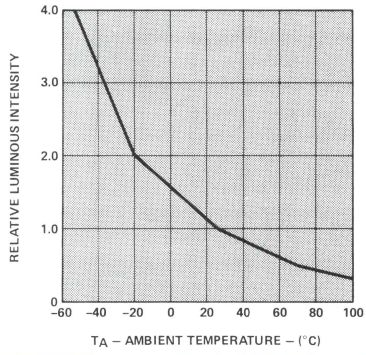
Timing Diagram



Character Font Description



Relative Luminous Intensity vs. Temperature



Electrical Description

Display Internal Block Diagram

Figure 1 shows the internal block diagram for the HMDL-2416 display. The CMOS IC consists of a four-word ASCII memory, a four-word cursor memory, a 64-word character generator, 17 segment drivers, four digit drivers, and the scanning circuitry necessary to multiplex the four monolithic LED characters. In normal operation, the divide-by-four counter sequentially accesses each of the four RAM locations and simultaneously enables the appropriate display digit driver. The output of the RAM is decoded by the character generator which, in turn, enables the appropriate display segment drivers. For each display location, the cursor enable (CUE) selects whether the data from the ASCII RAM (CUE = 0) or the stored cursor (CUE = 1) is to be displayed. The cursor character is denoted by all sixteen segments and the DP ON. Seven-bit ASCII data is stored in RAM. Since the display utilizes a 64-character decoder, half of the possible 128 input combinations are invalid. For each display location where $D_5 = D_6$ in the ASCII RAM, the display character is blanked. The entire display is blanked when $\overline{BL} = 0$.

Data is loaded into the display through the data inputs (D_6- D_0), digit selects (A_1, A_0), chip enables ($\overline{CE}_1$, $\overline{CE}_2$, cursor select ($\overline{CU}$), and write ($\overline{WR}$). The cursor select ($\overline{CU}$) determines whether data is stored in the ASCII RAM ($\overline{CU}$ = 1) or cursor memory ($\overline{CU}$ = 0). When $\overline{CE}_1 = \overline{CE}_2 = \overline{WR} = 0$ and $\overline{CU} = 1$, the information on the data inputs is stored in the ASCII RAM at the location specified by the digit selects (A_1, A_0). When $\overline{CE}_1 = \overline{CE}_2 = \overline{WR} = 0$ and $\overline{CU} = 0$, the information on the data input, D_0, is stored in the cursor at the location specified by the digit selects (A_1, A_0). If $D_0 = 1$, a cursor character is stored in the cursor memory. If $D_0 = 0$, a previously stored cursor character will be removed from the cursor memory.

If the clear input ($\overline{CLR}$) equals zero for one internal display cycle (4 ms minimum), the data in the ASCII RAM will be rewritten with zeroes and the display will be blanked. Note that the blanking input ($\overline{BL}$) must be equal to logical one during this time.

Data Entry

Figure 2 shows a truth table for the HMDL-2416 display. Setting the chip enables ($\overline{CE}_1$, $\overline{CE}_2$) to their low state and the cursor select ($\overline{CU}$) to its high state will enable data loading. The desired data inputs (D_6-D_0) and address inputs (A_1, A_0) as well as the chip enables ($\overline{CE}_1$, $\overline{CE}_2$) and cursor select ($\overline{CU}$) must be held stable during the write cycle to ensure that the correct data is stored into the display. Valid ASCII data codes are shown in Figure 3. The display accepts standard seven-bit ASCII data. Note that $D_6 = \overline{D_5}$ for the codes shown in Figure 2. If $D_6 = D_5$ during the write cycle, then a blank will be stored in the display. Data can be loaded into the display in any order. Note that when $A_1 = A_0 = 0$, data is stored in the furthest right-hand display location.

Cursor Entry

As shown in Figure 2, setting the chip enables ($\overline{CE}_1$, $\overline{CE}_2$) to their low state and the cursor select ($\overline{CU}$) to its low state will enable cursor loading. The cursor character is indicated by the display symbol having all 16 segments and the DP ON. The least significant data input (D_0), the digit selects (A_1, A_0), the chip enables ($\overline{CE}_1$, $\overline{CE}_2$), and the cursor select ($\overline{CU}$) must be held stable during the write cycle to ensure that the correct data is stored in the display. If D_0 is in a low state during the write cycle, then a cursor character will be removed at the indicated location. If D_0 is in a high state during the write cycle, then a cursor character will be stored at the indicated location. The presence or absence of a cursor character does not affect the ASCII data stored at that location. Again, when $A_1 = A_0 = 0$, the cursor character is stored in the furthest right-hand display location.

All stored cursor characters are displayed if the cursor enable (CUE) is high. Similarly, the stored ASCII data words are displayed, regardless of the cursor characters, if the cursor enable (CUE) is low. The cursor enable (CUE) has no effect on the storage or removal of the cursor characters within the display. A flashing cursor is displayed by pulsing the cursor enable (CUE). For applications not requiring a cursor, the cursor enable (CUE) can be connected to ground and the cursor select ($\overline{CU}$) can be connected to V_{CC}. This inhibits the cursor function and allows only ASCII data to be loaded into the display.

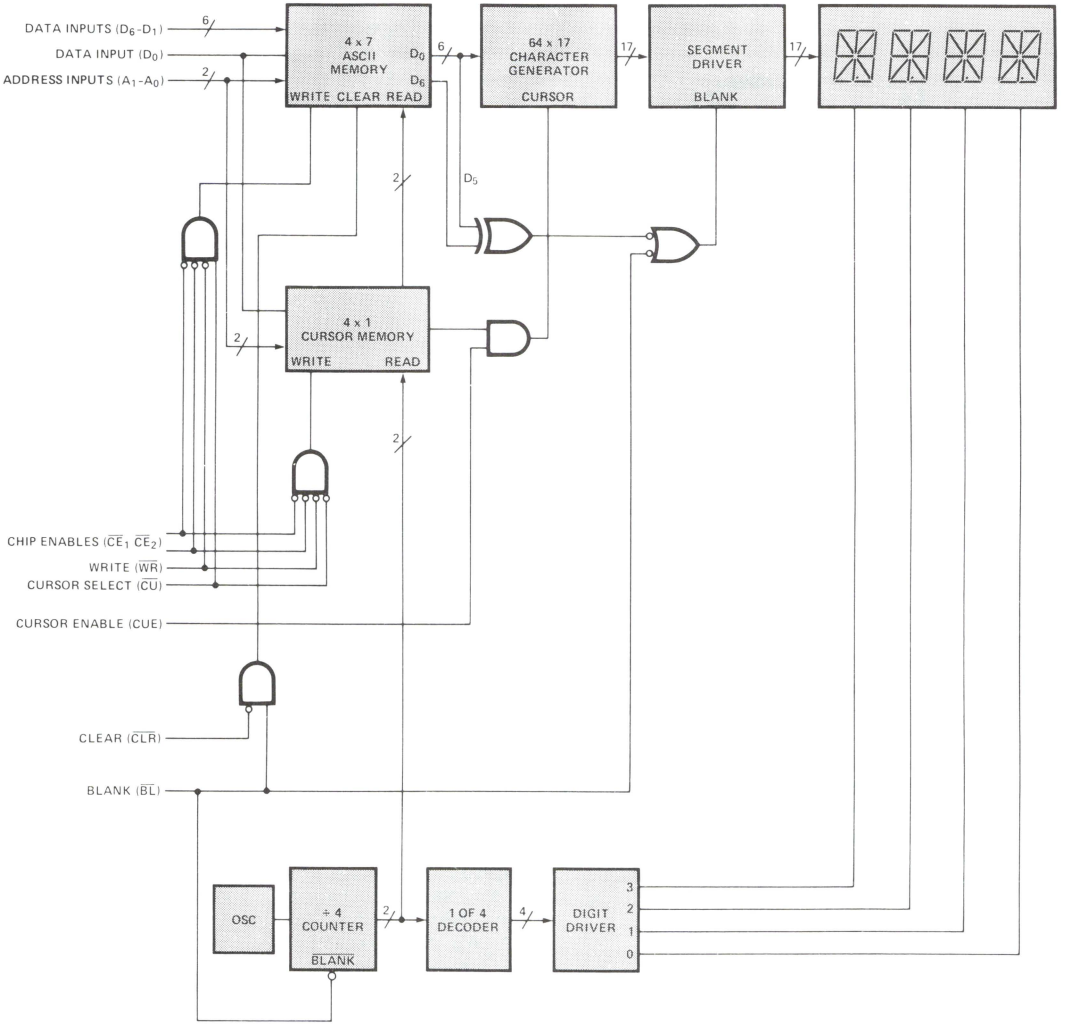


Figure 1. HMDL-2416 Internal Block Diagram

Display Clear

As shown in Figure 2, the ASCII data stored in the display will be cleared if the clear ($\overline{CLR}$) is held low and the blanking input ($\overline{BL}$) is held high for 4 ms minimum. The cursor memory is not affected by the clear ($\overline{CLR}$) input. Cursor characters can be stored or removed even while the clear ($\overline{CLR}$) is low. Note that the display will be cleared regardless of the state of the chip enables ($\overline{CE_1}$, $\overline{CE_2}$). However, to ensure that all four display characters are cleared, $\overline{CLR}$ should be held low for 4 ms following the last write cycle.

Display Blank

As shown in Figure 2, the display will be blanked if the blanking input ($\overline{BL}$) is held low. Note that the display will be blanked regardless of the state of the chip enables ($\overline{CE_1}$, $\overline{CE_2}$) or write ($\overline{WR}$) inputs. The ASCII data stored in the display and the cursor memory are not affected by the blanking input. ASCII data and cursor data can be stored even while the blanking input ($\overline{BL}$) is low. Note that while the blanking input ($\overline{BL}$) is low, the clear ($\overline{CLR}$) function is inhibited. A flashing display can be obtained by applying a low frequency square wave to the blanking input ($\overline{BL}$). Because the blanking input ($\overline{BL}$) also resets the internal display multiplex counter, the frequency applied to the blanking input ($\overline{BL}$) should be much slower than the display multiplex rate. Finally, dimming of the display through the blanking input ($\overline{BL}$) is not recommended.

For further application information please consult Application Note 1026.

Function	$\overline{BL}$	$\overline{CLR}$	CUE	$\overline{CU}$	$\overline{CE_1}$	$\overline{CE_2}$	$\overline{WR}$	A_1	A_0	D_6	D_5	D_4	D_3	D_2	D_1	D_0	DIG_3	DIG_2	DIG_1	DIG_0
Write Data Memory	L	X	X	H	L	L	L	L	L	a	a	a	a	a	a	a	NC	NC	NC	A
				—OR—				L	H	b	b	b	b	b	b	b	NC	NC	B	NC
	X	H	X	H	L	L	L	H	L	c	c	c	c	c	c	c	NC	C	NC	NC
								H	H	d	d	d	d	d	d	d	D	NC	NC	NC
Disable Data Memory Write	X	X	X	H	X	X	H	X	X	X	X	X	X	X	X	X	Previously Written Data			
	X	X	X	H	X	H	X													
	X	X	X	H	H	X	X													
Write Cursor	X	X	X	L	L	L	L	L	L	X	X	X	X	X	X	H	NC	NC	NC	▩
								L	H	X	X	X	X	X	X	H	NC	NC	▩	NC
								H	L	X	X	X	X	X	X	H	NC	▩	NC	NC
								H	H	X	X	X	X	X	X	H	▩	NC	NC	NC
Clear Cursor	X	X	X	L	L	L	L	L	L	X	X	X	X	X	X	L	NC	NC	NC	⬚
								L	H	X	X	X	X	X	X	L	NC	NC	⬚	NC
								H	L	X	X	X	X	X	X	L	NC	⬚	NC	NC
								H	H	X	X	X	X	X	X	L	⬚	NC	NC	NC
Disable Cursor Memory	X	X	X	L	X	X	H	X	X	X	X	X	X	X	X	X	Previously Written Cursor			
	X	X	X	L	X	H	X													
	X	X	X	L	H	X	X													

L = LOGIC LOW INPUT
H = LOGIC HIGH INPUT
X = DON'T CARE

"a" = ASCII CODE CORRESPONDING TO SYMBOL "A"
NC = NO CHANGE
▩ = CURSOR CHARACTER (ALL SEGMENTS ON)

Figure 2a. Cursor/Data Memory Write Truth Table

Function	$\overline{BL}$	$\overline{CLR}$	CUE	$\overline{CU}$	$\overline{CE_1}$	$\overline{CE_2}$	$\overline{WR}$	DIG_3	DIG_2	DIG_1	DIG_0	
CUE	H	H	L	X	X	X	X	A	B	C	D	Display previously written data
	H	H	H	X	X	X	X	▩	▩	▩	▩	Display previously written cursor
Clear	H	L	X	X	X	X	X*	⬚	⬚	⬚	⬚	Clear data memory, cursor memory unchanged
	*NOTE: CLR should be held low for 4 ms following the last WRITE cycle to ensure all data is cleared.											
Blanking	L	X	X	X	X	X	X	⬚	⬚	⬚	⬚	Blank display, data and cursor memories unchanged.

Figure 2b. Displayed Data Truth Table

BITS	D_3 D_2 D_1 D_0	0 0 0 0	0 0 0 1	0 0 1 0	0 0 1 1	0 1 0 0	0 1 0 1	0 1 1 0	0 1 1 1	1 0 0 0	1 0 0 1	1 0 1 0	1 0 1 1	1 1 0 0	1 1 0 1	1 1 1 0	1 1 1 1
D_6 D_5 D_4	HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0 1 0	2	(space)	!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
0 1 1	3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
1 0 0	4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1 0 1	5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_

Figure 3. HPDL-2416 ASCII Character Set

Mechanical and Electrical Considerations

The HMDL-2416 is an 18 pin dual-in-line package, that can be stacked horizontally and vertically to create arrays of any size. The HMDL-2416 is designed to operate continuously from -55° to +100°C for all possible input conditions including the illuminated cursor in all four character locations. The HMDL-2416 is assembled by die attaching and wire bonding the four GaAsP/GaAs monolithic LED chips and the CMOS IC to a 18 lead ceramic-glass dual-in-line package. It is designed either to plug into DIP sockets or to solder into PC boards.

The inputs of the CMOS IC are protected against static discharge and input current latchup. However, for best results standard CMOS handling precautions should be used. Prior to use, the HMDL-2416 should be stored in anti-static tubes or conductive material. During assembly, a grounded conductive work area should be used. The assembly personnel should use conductive wrist straps. Lab coats made of synthetic materials should be avoided since they are prone to static charge build-up. Input current latchup is caused when the CMOS inputs are subjected to a voltage either below ground (V_{IN} < ground) or to a higher voltage than V_{CC} (V_{IN} > V_{CC}) and a high current is forced into the input. To prevent input current latchup and ESD damage, unused inputs should be connected either to ground or to V_{CC}, voltages should not be applied to the inputs until V_{CC} has been applied to the display, and transient input voltages should be eliminated.

Soldering and Post Solder Cleaning Instructions for the HMDL-2416

The HMDL-2416 may be hand soldered or wave soldered with SN63 solder. Hand soldering may be safely performed only with an electronically temperature-controlled and securely grounded soldering iron. For best results, the iron tip temperature should be set at 315°C (600°F). For wave soldering, a rosin-based RMA flux or a water soluble organic acid (OA) flux can be used. The solder wave temperature should be 245°C ±5°C (473°F ±9°F), and the dwell in the wave should be set at 1 1/2 to 3 seconds for optimum soldering.

Post solder cleaning may be accomplished using water or Freon/alcohol mixtures formulated for vapor cleaning processing or Freon/alcohol mixtures formulated for room temperature cleaning. Freon/alcohol vapor cleaning processing for up to 2 minutes in vapors at boiling is permissible. Suggested solvents include Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15, Genesolv DES, and water.

For further information on soldering, refer to Application Note 1027, "Soldering LED Components".

Optical Considerations/ Contrast Enhancement

Each HMDL-2416 display is tested for luminous intensity and marked with an intensity category on the back of the display package. To ensure intensity matching for multiple package applications, all displays for a given panel should have the same category.

The HMDL-2416 display is designed to provide maximum contrast when placed behind an appropriate contrast enhancement filter. Some suggested filters are Panelgraphic Dark Red 63, SGL Homalite H100-1650, Rohm and Haas 2423, Chequers Engraving 118, and 3M R6510. For further information on contrast enhancement, see Hewlett-Packard Application Note 1015.

High Reliability Testing

Two standard high reliability testing programs are available. The TXVB program is in conformance with MIL-D-87157 level A Test Tables. The TXVB product is tested to Tables I, II, IIIa, and IVa. The TXV program is an HP modification to the full conformance program and offers the 100% screening of Quality Level A, Table I, and Group A, Table II.

Part Marking System

Standard Product	With Table I and II	With Tables I, II, IIIa, IVa
HMDL-2416	HMDL-2416TXV	HMDL-2416TXVB

100% Screening

Table I. Quality Level A of MIL-D-87157

Test Screen	MIL-STD-750 Method	Conditions
1. Precap Visual	2072	Interpreted by HP Procedure 5956-7235-52
2. High Temperature Storage	1032	T_A = 125°C, Time = 24 hours
3. Temperature Cycling	1051	Condition B, 10 cycles, 15 min. dwell
4. Constant Acceleration	2006	5,000 G's at Y_1 orientation
5. Fine Leak	1071	Condition H
6. Gross Leak	1071	Condition C
7. Interim Electrical/Optical Tests[2]	—	I_{CC}, I_V @ V_{CC} = 5.0 V T_A = 25°C
8. Burn-In[1]	1015	Condition B at V_{CC} = 5.5 V T_A = 100°C t = 160 hours
9. Final Electrical Test[2]	—	I_{CC}%, I_{CC} ($\overline{CU}$), I_{CC} ($\overline{BL}$) I_{IL}, I_V @ V_{CC} = 5.0 V T_A = 25°C
10. Delta Determinations	—	ΔI_{CC} = ± 10% ΔI_V = - 20% T_A = 25°C
11. External Visual[1]	2009	

Notes:
1. MIL-STD-883 Test Method Applies
2. Limits and conditions are per the electrical optical characteristics.

Table II. Group A Electrical Tests — MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25°C [1]	I_{CC}%, I_{CC} ($\overline{CU}$), I_{CC} ($\overline{BL}$), I_{IL}, I_V and visual function @ V_{CC} = 5.0 V	5
Subgroup 2 DC Electrical Tests at High Temperature [1]	Same as Subgroup 1, except delete I_V and visual function, T_A = +100°C	7
Subgroup 3 DC Electrical Tests at Low Temperature [1]	Same as Subgroup 1, except delete I_V and visual function, T_A = -55°C	7
Subgroup 4, 5, and 6 not applicable		
Subgroup 7 Optical and Functional Tests at 25°C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883, Method 2009	7

Note:
1. Limits and conditions are per the electrical/optical characteristics.

Table IIIa. Group B, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Resistance to Solvents	1022		4 Devices/ 0 Failures
Internal Visual and Design Verification [1]	2075 [6]		1 Device/ 0 Failures
Subgroup 2 [2,3]			
Solderability	2026	T_A = 245°C for 5 seconds	LTPD = 15
Subgroup 3			
Thermal Shock (Temp. Cycle)	1051	Condition B1, 15 minute dwell	LTPD = 15
Moisture Resistance [4]	1021		
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints [5]	—	I_{CC}%, I_{CC} ($\overline{CU}$), I_{CC} ($\overline{BL}$), I_{IL}, I_V @ V_{CC} = 5.0 V and visual function. T_A = 25°C	
Subgroup 4			
Operating Life Test (340 hrs.)	1027	T_A = 100°C @ V_{CC} = 5.5 V	LTPD = 10
Electrical/Optical Endpoints [5]	—	Same as Subgroup 3	
Subgroup 5			
Non-operating (Storage) Life Test (340 hrs.)	1032	T_A = +125°C	LTPD = 10
Electrical/Optical Endpoints [5]	—	Same as Subgroup 3	

Notes:
1. Visual inspection is performed through the display window.
2. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
3. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
4. Initial conditioning is a 15° inward bend for one cycle.
5. Limits and conditions are per the electrical/optical characteristics.
6. Equivalent to MIL-STD-883, Method 2014.

Table IVa. Group C, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Physical Dimensions	2066		2 Devices/ 0 Failures
Subgroup 2[2]			
Lead Integrity[7, 9]	2004	Condition B2	LTPD = 15
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G, Time = 0.5 ms, 5 blows in each orientation X_1, Y_1, Z_1	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	5,000 G's at Y_1 orientation	
External Visual[4]	1010 or 1011		
Electrical/Optical Endpoints[8]	—	I_{CC}%, I_{CC} ($\overline{CU}$), I_{CC} ($\overline{BL}$), I_{IL}, I_V @ V_{CC} = 5.0 V and visual function. T_A = 25°C	
Subgroup 4[1,3]			
Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		
Subgroup 5			
Bond Strength[5]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			
Operating Life Test[6]	1026	T_A = 100°C @ V_{CC} = 5.5 V	λ = 10
Electrical/Optical Endpoints[8]	—	Same as Subgroup 3	

Notes:

1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. If a given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1000 hours in order to satisfy the Group C life test requirements. In such cases, either the 340 hour endpoint measurements shall be made a basis for Group B lot acceptance or the 1000 hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.
7. MIL-STD-883 test method applies.
8. Limits and conditions are per the electrical/optical characteristics.
9. Initial conditioning is a 15° inward bend for three cycles.

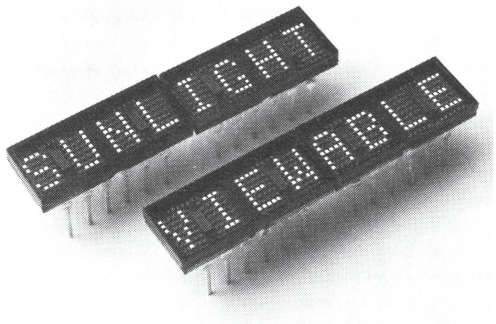
HEWLETT PACKARD

EXTENDED TEMPERATURE FOUR CHARACTER 5.0 mm (0.20 INCH) 5 x 7 ALPHANUMERIC DISPLAY FOR SUNLIGHT VIEWABLE APPLICATIONS

YELLOW	HDSP-2351/2351TXV/2351TXVB
HIGH EFFICIENCY RED	HDSP-2352/2352TXV/2352TXVB
HIGH PERFORMANCE GREEN	HDSP-2353/2353TXV/2353TXVB

Features

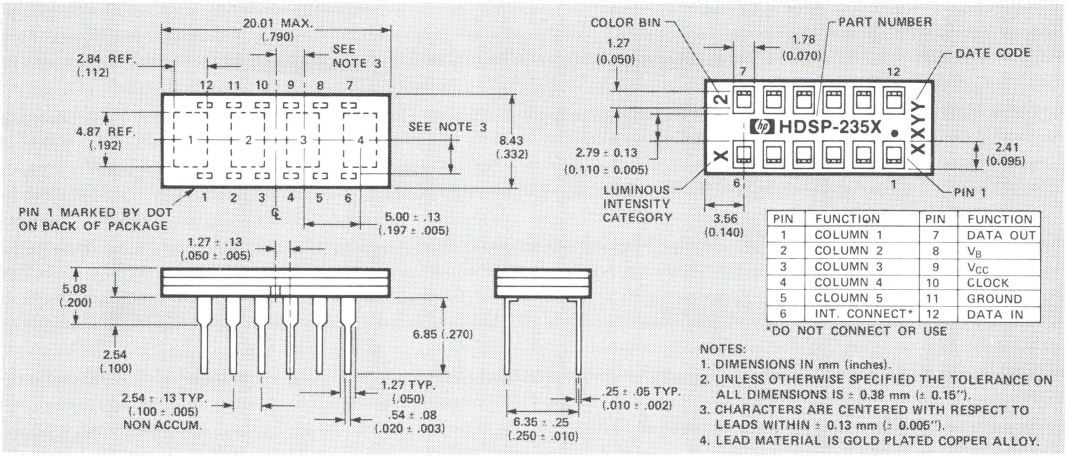
- TXVB VERSION CONFORMS TO MIL-D-87157 QUALITY LEVEL A TEST TABLES
- SUNLIGHT VIEWABLE UP TO 10,000 FOOTCANDLES
- WIDE OPERATING TEMPERATURE RANGE -55° C TO +85° C
- THREE COLORS
  Yellow
  High Efficiency Red
  High Performance Green
- COMPACT CERAMIC PACKAGE
- WIDE VIEWING ANGLE
- END AND ROW STACKABLE
- 5 x 7 LED MATRIX DISPLAYS FULL ASCII SET
- INTEGRATED SHIFT REGISTERS WITH CONSTANT CURRENT LED DRIVERS
- TTL COMPATIBLE
- CATEGORIZED FOR LUMINOUS INTENSITY
- HDSP-2351/-2353 CATEGORIZED FOR COLOR



Description

The HDSP-2351/-2352/-2353 displays are designed for use in military applications requiring readability in bright sunlight. With a proper contrast enhancement filter and heat sinking, these displays are readable in sunlight ambients up to 10,000 footcandles. The character font is a 5.0 mm (0.20 inch) 5 x 7 LED array for displaying alphanumeric information. These devices are available in yellow, high efficiency red, and high performance green. Each four character cluster is packaged in a 12-pin dual-in-line package. An on-board serial-in-parallel-out 7-bit shift register associated with each digit controls constant current LED row drivers. Full character display is achieved by external column strobing.

Package Dimensions



PIN	FUNCTION	PIN	FUNCTION
1	COLUMN 1	7	DATA OUT
2	COLUMN 2	8	V_B
3	COLUMN 3	9	V_{CC}
4	COLUMN 4	10	CLOCK
5	CLOUMN 5	11	GROUND
6	INT. CONNECT*	12	DATA IN

*DO NOT CONNECT OR USE

NOTES:
1. DIMENSIONS IN mm (inches).
2. UNLESS OTHERWISE SPECIFIED THE TOLERANCE ON ALL DIMENSIONS IS ± 0.38 mm (± 0.15").
3. CHARACTERS ARE CENTERED WITH RESPECT TO LEADS WITHIN ± 0.13 mm (± 0.005").
4. LEAD MATERIAL IS GOLD PLATED COPPER ALLOY.

Typical Applications

- **MILITARY AVIONICS — Cockpit displays, aircraft system monitors, fuel management and airborne navigational radio systems**
- **MILITARY TEST AND GROUND SUPPORT FIELD EQUIPMENT**
- **MILITARY VEHICLES AND EQUIPMENT**
- **OTHER APPLICATIONS REQUIRING READABILITY IN DIRECT SUNLIGHT**

Absolute Maximum Ratings (HDSP-2351/-2352/-2353)

Supply Voltage V_{CC} to Ground ..... −0.5 V to +6.0 V
Inputs, Data Out and V_B ..... −0.5 V to V_{CC}
Column Input Voltage, V_{COL} ..... −0.5 V to +6.0 V
Free Air Operating Temperature Range, T_A[1,2] ..... −55° C to +85° C
Storage Temperature Range, T_S ..... −55° C to +100° C
Maximum Allowable Package Dissipation at T_A = 25° C[1,2,3]
HDSP-2381/-2382/-2383 ..... 1.74 Watts
Maximum Solder Temperature 1.59 mm (0.063 in) Below Seating Plane t<5 sec ..... 260° C

Recommended Operating Conditions Over Operating Temperature Range (−55°C to +85°C) (HDSP-2351/-2352/-2353)

Parameter	Symbol	Min.	Nom.	Max.	Units	Fig.
Supply Voltage	V_{CC}	4.75	5.0	5.25	V	
Data Out Current, Low State	I_{OL}			1.6	mA	
Data Out Current, High State	I_{OH}			-0.5	mA	
Column Input Voltage, Column On HDSP-2381/-2382/-2383	V_{COL}	2.75		3.5	V	4
Setup Time	t_{SETUP}	70	45		ns	1
Hold Time	t_{HOLD}	30	0		ns	1
Width of Clock	$t_{W(CLOCK)}$	75			ns	1
Clock Frequency	f_{CLOCK}	0		3	MHz	1
Clock Transition Time	t_{THL}			200	ns	1
Free Air Operating Temperature Range[1,2]	T_A	-20		85	°C	3

Electrical Characteristics Over Operating Temperature Range (−55°C to +85°C)

YELLOW HDSP-2351/HIGH EFFICIENCY RED HDSP-2352/HIGH PERFORMANCE GREEN HDSP-2353

Description		Symbol	Test Conditions		Min.	Typ.*	Max.	Units	Fig.
Supply Current		I_{CC}	V_{CC} = 5.25V, V_{CLOCK} = V_{DATA} = 2.4V, All SR Stages = Logical 1	V_B = 0.4V		50	60	mA	
				V_B = 2.4V		90	100	mA	
Column Input Current (any Column Pin)		I_{COL}	V_{CC} = 5.25 V, V_{COL} = 3.5V	V_B = 0.4V			500	μA	4
Column Input Current (any Column Pin)		I_{COL}	All SR Stages = Logical 1	V_B = 2.4V		550	653	mA	
V_B, Clock or Data Input Threshold High		V_{IH}	V_{CC} = V_{COL} = 4.75V		2.0			V	
V_B, Data Input Threshold Low		V_{IL}					0.8	V	
Clock Input Threshold Low		V_{IL}	V_{CC} = 4.75 V				0.6	V	
Input Current Logical 1	V_B, Clock	I_{IH}	V_{CC} = 5.25V, V_{IH} = 2.4V			20	80	μA	
	Data In	I_{IH}				10	40	μA	
Input Current Logical 0	V_B, Clock	I_{IL}	V_{CC} = 5.25V, V_{IL} = 0.4V			-500	-800	μA	
	Data In	I_{IL}				-250	-400	μA	
Data Out Voltage		V_{OH}	V_{CC} = 4.75V, I_{OH} = -0.5 mA, I_{COL} = 0 mA		2.4	3.4		V	
		V_{OL}	V_{CC} = 4.75V, I_{OL} = 1.6 mA, I_{COL} = 0 mA			0.2	0.4	V	
Power Dissipation Per Package**		P_D	V_{CC} = 5.0V, V_{COL} = 3.5V, 17.5% DF 15 LEDs on per character, V_B = 2.4V			1.05		W	2
Thermal Resistance IC Junction-to-Pin		$R\theta_{J-PIN}$				10		°C/W/ Device	2
Leak Rate							$5x10^{-8}$	cc/sec	

*All typical values specified at V_{CC} = 5.0V and T_A = 25° C unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

1. The HDSP-2351/-2352/-2353 should be derated linearly above 50° C at 24.3 mW/° C, based on a device mounted such that the thermal resistance from IC junction to ambient is 45° C/W (10° C/W $R\theta_{J-PIN}$ and 35° C/W $_{PIN-A}$). See Figure 2 for power deratings based on lower thermal resistance mounting.
2. Operation above 50° C ambient is possible provided the following conditions are met. The junction temperature should not exceed 125° C (T_J) and the temperature at the pins should not exceed 100° C (T_C).
3. Maximum allowable dissipation is derived from V_{CC} = 5.25 V, V_B = 2.4 V, V_{COL} = 3.5 V, 20 LEDs on per character, 20% DF.

Optical Characteristics

YELLOW HDSP-2351

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPEAK}	V_{CC} = 5.0V, V_{COL} = 3.5V T_i = 25° C[6], V_B = 2.4V	2400	3400		μcd	3
Dominant Wavelength[5,7]	λ_d			585		nm	
Peak Wavelength	λ_{PEAK}			583		nm	

HIGH EFFICIENCY RED HDSP-2352

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPEAK}	V_{CC} = 5.0V, V_{COL} = 3.5V T_i = 25° C[6], V_B = 2.4V	1920	2850		μcd	3
Dominant Wavelength[7]	λ_d			626		nm	
Peak Wavelength	λ_{PEAK}			635		nm	

HIGH PERFORMANCE GREEN HDSP-2353

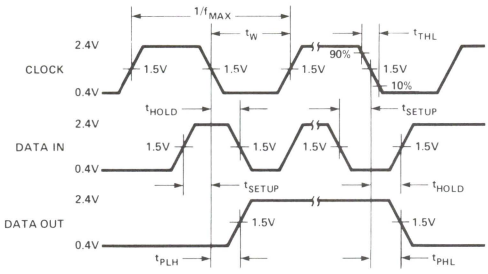
Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{VPEAK}	V_{CC} = 5.0V, V_{COL} = 3.5V T_i = 25° C[6], V_B = 2.4V	2400	3000		μcd	3
Dominant Wavelength[5,7]	λ_d			574		nm	
Peak Wavelength	λ_{PEAK}			568		nm	

*All typical values specified at V_{CC} = 5.0V and T_A = 25° C unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

4. These LED displays are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
5. The HDSP-2351/-2353 are categorized for color with the color category designated by a number code on the bottom of the package.
6. T_I refers to the initial case temperature of the device immediately prior to the light measurement.
7. Dominant wavelength λ_d, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
8. The luminous sterance of the LED may be calculated using the following relationships:
   L_v (cd/m^2) = I_v (Candela)/A (Metre)^2
   L_v (Footlamberts) = πI_v (Candela)/A (Foot)^2
   A = 5.3 x 10^{-8} M^2 = 5.8 x 10^{-7} (Foot)^2



Parameter	Condition	Min.	Typ.	Max.	Units
f_{CLOCK} CLOCK Rate				3	MHz
t_{PLH}, t_{PHL} Propagation delay CLOCK to DATA OUT	C_L = 15pF R_L=2.4KΩ			125	ns

Figure 1. Switching Characteristics HDSP-2351/-2352/-2353 (T_A = -20° C to +85° C).

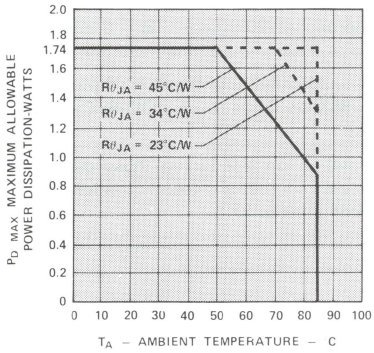


Figure 2. Maximum Allowable Power Dissipation vs. Ambient Temperature as a Function of Thermal Resistance IC Junction to Ambient Air. $R\theta_{JA}$.

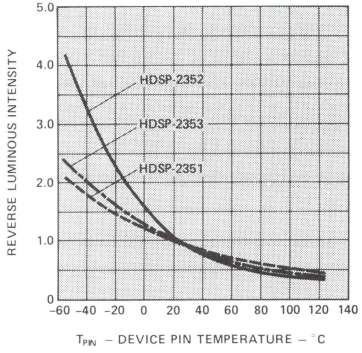


Figure 3. Relative Luminous Intensity vs. Device Substrate (PIN) Temperature.

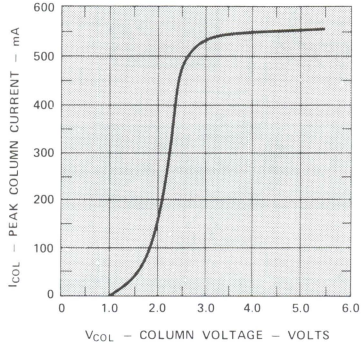


Figure 4. Peak Column Current vs. Column Voltage.

Electrical Description

The electrical configuration of the HDSP-235X series alphanumeric displays allows for an effective interface to a microprocessor data source. Each display device contains four 5x7 LED dot matrix characters and two integrated circuits, as diagrammed in Figure 5. The two integrated circuits, with TTL compatible inputs, form a 28 bit serial-in-parallel-out column data shift register. The data input is connected to shift register bit position 1 and the data output is connected to bit position 28. The shift register parallel outputs are connected to constant current sinking LED row drivers that sink a nominal 19.6 mA. A logic 1 stored in the shift register enables the corresponding LED row driver and a logic 0 stored in the shift register disables the corresponding LED row driver.

Column data is loaded into an on-board shift register with high to low transitions of the Clock input. To load character information into the display, column data for the character 4 is loaded first and the column data for character 1 is loaded last in the following manner: The 7 data bits for column 1, character 4 are loaded into the on-board shift register. Next, the 7 data bits for column 1, character 3 are loaded into the on-board shift register, shifting the character 4 data over one character position. This process is repeated until all 28 bits of column data are loaded into the on-board shift register. Then, the column 1 input is energized to illuminate column 1's in all four characters. The procedure is repeated for columns 2, 3, 4 and 5.

The light output of the display may be dimmed by pulse width modulating (PWM) the blanking input V_B, with the brightness being in direct proportion to the LED on-time. When the blanking input is at logic high the display is illuminated and when the blanking input is at logic low the display is blanked. These displays may be dimmed by PWM on the order of a 2000:1 change in brightness while maintaining light output and color uniformity between characters.

The LED on-time duty factor, DF, may be determined when the time to load the on-board shift register, t, the column on-time without blanking, T, and the time display is blanked, TB, are known:

$$DF = \frac{T}{5(t + T + TB)}$$

Where: $5(t + T + TB)$ is 1/column refresh rate

The column driver inputs should be strobed at a refresh rate of 100 Hz or faster to achieve a flicker free display. The value of DF approaches 20% when TB = 0 and t is very small compared to T.

The ESD susceptibility of these IC devices is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263.

For information on interfacing these displays to microprocessor data sources and techniques for intensity control, see Application Note 1016.

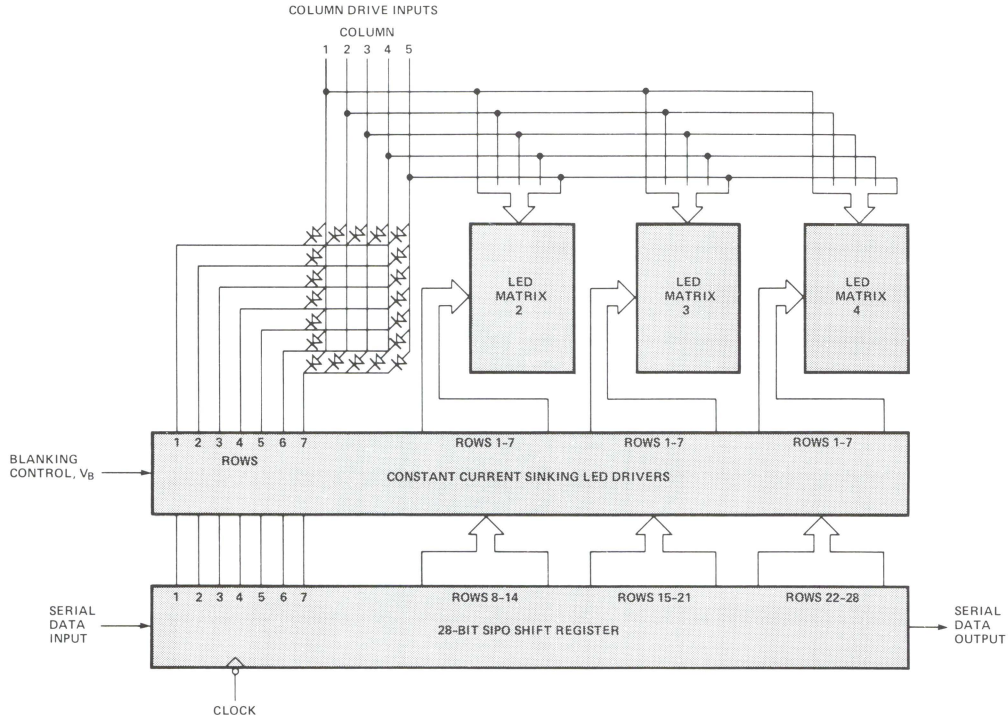


Figure 5. Block Diagram of an HDSP-235X Series LED Alphanumeric Display

Power Dissipation and Low Thermal Resistance Design Considerations

The light output of the HDSP-235X devices is a function of temperature, decreasing 1.5% for each 1° C increase in junction temperature. Therefore, it is desirable to maintain as low device junction temperature as possible to insure sufficient light output for sunlight readability. This is preferably achieved by designing for a low junction to ambient thermal resistance, or alternatively by controlling total display power dissipation by derating, see data sheet Figure 2.

Power Dissipation Calculation:

Power dissipation may be calculated using the equations of Figure 6a. For typical applications, the average pixel count per character is 15. The maximum power dissipation is calculated with a pixel count of 20 per character. As demonstrated in Figure 6c, the maximum power dissipation is 1.741 W with DF = 20%, V_{CC} = 5.25 V and V_{COL} = 3.5 V. The average power dissipation is 1.161 W per device with DF = 20%, V_{CC} = 5.0 V and V_{COL} = 3.5 V.

As shown in Figure 4 on the data sheet, the column current, I_{COL}, is constant when the column input voltage, V_{COL}, is at 2.75 V or greater. Setting V_{COL} substantially greater than 2.75 V does not increase light output, but does add to device total power dissipation. For optimum performance, it is recommended that V_{COL} be set between 2.75 V and 3.5 V.

Junction Temperature and Device Thermal Resistance:

It is necessary to control the IC junction temperature, T_J(IC), to insure proper operation of the display:

$$T_J(IC)MAX = 125° C$$

The equations to calculate T_J(IC) are given in Figure 6b. T_J(IC) will be higher than the device substrate temperature where as the individual LED pixel junction temperatures, T_J(LED), will be nearly the same as the substrate temperature. A sample calculation is presented in Figure 6c.

An easy design rule is to obtain a IC junction to ambient thermal resistance, $R_{\theta J-A}$, that establishes the device pin temperature less than 100° C. The value of $R_{\theta J-A}$ = 23° C/W will permit device operation in an ambient temperature of 85° C, without derating. Figure 7 gives the maximum values for $R\theta_{J-A}$ for reliable device operation in ambient temperatures from 25° C to 85° C.

To achieve a low value of $R_{\theta PIN-A}$, the following designs may be incorporated into the display system:

1. Mount the displays on a double sided maximum metalized PC board, as illustrated in Figure 8.

For single line display assemblies, a double sided maximum metalized PC board is a cost effective way to achieve a low thermal resistance to ambient. "Lands" are used instead of "traces" as the current carrying elements. Each "land" is made as wide as possible, consistent with circuit layout restrictions, to achieve metalized surface area to radiate thermal energy. Isolation strips, 0,64 mm (0.025 inch) wide, are etched from the board to electrically isolate the lands. PC board thermal resistance values in the range of 35° C/W per device are achievable for single line display assemblies. Air flow across the display PC board assembly dissipates the heat.

2. Install a metal plate, or bar, between the display packages and the PC board, with the bar mechanically fastened to the chassis, as illustrated in Figure 9a.

For multiple display lines, a metal plate may be placed between the display packages and the PC board to conduct the heat to the chassis housing assembly. The metal plate may be electrically insulated from the PC board by a thermally conductive insulator. Heat sink bars are formed in the metal plate by milling out lead clearance slots. The ceramic package of a display rests on one of the heat sink bars with the device leads passing through the slots to make electrical contact with the PC board. The heat is transferred from the display ceramic package into the metal plate. The chassis housing acts as the thermal radiator to dissipate the heat into the surrounding environment. The metal plate must be mechanically fastened to the housing assembly, otherwise it will act only as a thermal capacitor and will not dissipate the heat.

3. Install a heat pipe between the display packages and the PC board, with the heat pipe mechanically fastened to the chassis housing, as shown in Figure 9b.

The heat pipe is a low mass alternative to the metal plate described above. A heat pipe is a small tube, filled with a chemical, that transfers heat from the source to a heat sink with minimal thermal impedance. It is not a heat sink. The heat pipe transfers the heat directly from the display ceramic package to the chassis housing which dissipates the heat into the surrounding air.

4. Utilize a heat pipe to transfer the heat from a maximum metalized PC board to a finned heat sink mounted on the back of the assembly housing, as shown in Figure 10.

The heat pipe is placed against the back side of a maximum metalized PC board, electrically isolated by a thermally conductive insulator. When the heat pipe is connected to a finned heat sink on the back of the chassis housing, PC board to external ambient thermal resistance values in the range of 10 to 15° C/W per device can be achieved. The heat generated by the displays is directly dissipated into the external ambient surrounding the chassis housing by the finned heat sink.

Contact the following manufacturers for information on:

Heat Pipe Technology:

Noren Products
3545 Haven Avenue
Menlo Park, CA 94025
(415) 365-0632

Thermally Conductive Insulators; "Sil-Pad":

Bergquist Company
5300 Edina Indl Blvd.
Minneapolis, MN 55435
(612) 835-2322

$PD = P(I_{CC}) + P(I_{REF}) + P(I_{COL})$; Total power dissipation per device.

Where: $P(I_{CC}) = I_{CC}\ (V_B = 0.4\ V) \cdot V_{CC}$; Power dissipated by the two ICs when the display is blanked.

$P(I_{REF}) = 5 \cdot [I_{CC}\ (V_B = 2.4\ V) - I_{CC}\ (V_B = 0.4\ V)] \cdot V_{CC} \cdot (n/35) \cdot DF$; Additional power dissipated by the two ICs with characters illuminated.

$P(I_{COL}) = 5 \cdot I_{COL} \cdot V_{COL}(n/35) \cdot DF$; Power dissipated by the LED pixels when the characters are illuminated.

n = 15 pixels per character for average power.

n = 20 pixels per character for maximum power.

Figure 6a. Equations for Calculating Device Power Dissipation.

Delta T_J (IC) = $R\theta_{J\text{-}PIN} \cdot PD$; IC junction temperature rise above device pin temperature.

Where: $R\theta_{J\text{-}PIN}$ = 10° C/W; The thermal resistance IC junction to device pin 1.

Delta T_{PIN} = $R\theta_{PIN\text{-}A} \cdot PD$; Device pin temperature rise above the ambient temperature, T_A.

Where: $R\theta_{PIN\text{-}A}$ = The thermal resistance, device pin to ambient through the PC board, on a per device basis.

T_J (IC) = T_A + [Delta T_J (IC) + Delta T_{PIN}]; IC junction temperature, the sum of the ambient temperature and the temperature rise above ambient.

Figure 6b. Equations for Calculating IC Junction

Device Maximum Power Dissipation:

IC Maximum Power Dissipation:

$P(I_{CC})$ = (0.060A) (5.25 V) = 0.315 W

$P(I_{REF})$ = 5(0.100A — 0.060A) (5.25 V) (20/35) (1/5) = 0.120W

I_{COL} Power Dissipation:

$P(I_{COL})$ = 5(0.653A) (3.5 V) (20/35) (1/5) = 1.306 W

Device Maximum Power Dissipation:

PD(MAX) = 0.315 W + 0.120 W + 1.306 W = 1.741 W

IC Junction Temperature, T_A = 85° C:

IC Junction Temperature Rise Above Substrate Pin:

Delta T_J(IC) = (10° C/W) (1.741 W) = 17.4° C Rise

Device Pin Temperature Rise Above Ambient:

Delta T(PIN) = (13° C/W) (1.741 W) = 22.6° C Rise

IC Junction Temperature:

T_J(IC) = 85° C + (17.4° C + 22.6° C) = 125.0° C

Note:
I_{CC} and I_{COL} values taken from the data sheet Electrical Characteristics. $R\theta_{J\text{-}PIN}$ = 10° C/W and $R\theta_{PIN\text{-}A}$ = 13° C/W.

Figure 6c. Sample Calculation of Device Maximum Power Dissipation and IC Junction Temperature for an HDSP-235X Series Device Operating in an Ambient of T_A = 85° C.

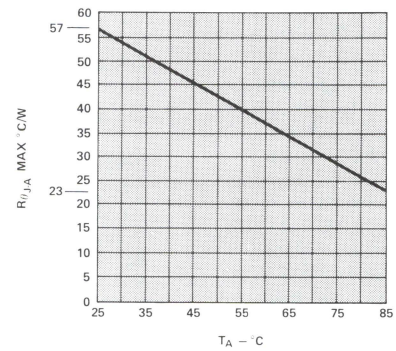


Figure 7. Maximum Thermal Resistance IC Junction to Ambient, $R\theta_{J\text{-}A}$, vs. Ambient Temperature. Based on: P_D MAX. = 1.741 W, T_J (IC) MAX. = 125° C.

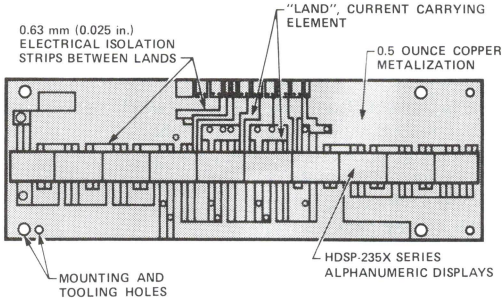


Figure 8. Maximum Metalized PC Board, Double Sided, for Mounting HDSP-235X Series Displays.

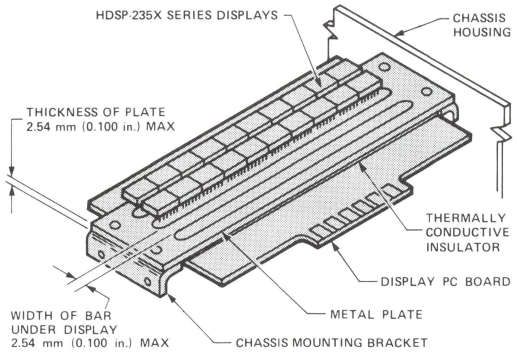


Figure 9a. Metal Plate Mounted Between Display Devices and PC Board, Mechanically Fastened to Chassis Housing.

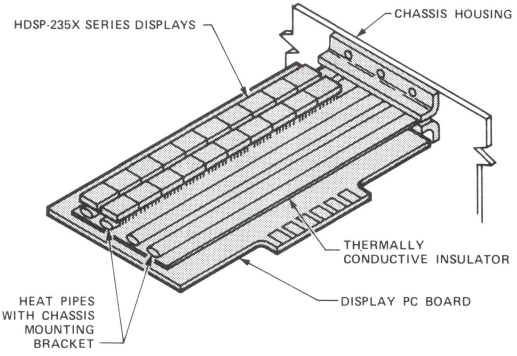


Figure 9b. Heat Pipes Mounted Between Display Devices and PC Board, Mechanically Fastened to Chassis Housing.

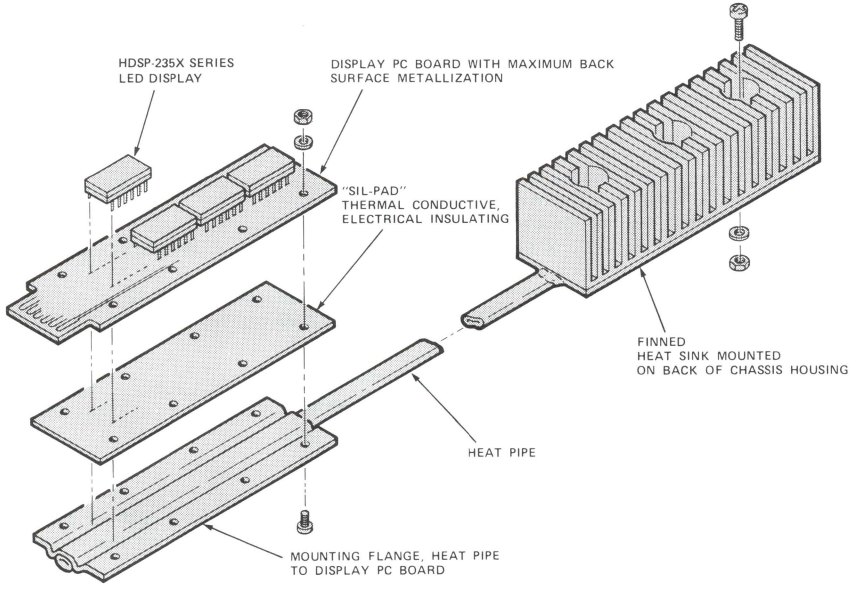


Figure 10. Using a Heat Pipe to Transfer Display Generated Heat to an Externally Mounted Finned Heat Sink.

Contrast Enhancement

The high light output of the HDSP-235X series displays in combination with improved contrast enhancement techniques, such as a new filter for the green HDSP-2353 display, make it possible to achieve readability in sunlight. Readability of the HDSP-235X series displays in sunlight is achieved by placing an antireflection coated, AR, circular polarized, CP, optically tinted glass filter in front of the display. The AR/CP optically tinted glass filter provides luminous contrast between the on-LED pixels and the display background, establishes a recognizable color difference between the on-LED pixels and the display background and reduces the level of ambient light reflected off the front surface of the filter. This technology and the concept of Discrimination Index, as a measure of readability, are discussed in Application Note 1015.

An AR/CP optically tinted glass filter should have a single pass relative transmission between 11% and 17% at the peak wavelength of the LED radiated spectrum, provided by the optical tinting. The double pass relative transmission should be less than 1%, provided by the circular polarizer. The filter can be either neutral density or bandpass, depending upon the properties of the optical tinting. The appropriate bandpass filter, with a peak relative transmission positioned at the peak wavelength of the LED radiated spectrum, will typically have a higher luminous contrast ratio than a neutral density filter, as it absorbs ambient light in the blue and blue-green regions. The AR coating reduces reflections off the front surface of the glass filter to a nominal 0.25%.

Luminous contrast values greater than 4.0 can be achieved in 107,000lm/m^2 (10,000fc) sunlight, excluding the condition of a reflected image of the sun off the front surface of the filter. The luminous contrast, which includes both diffuse and specular reflectance components off the front surface of the glass filter, is the predominant factor in the determination of the Discrimination Index. The luminous contrast combined with the color difference between illuminated LED pixels and the display background, as viewed through the AR/CP filter, produce Discrimination Index values in the neighborhood of 5.0. Values of Discrimination Index greater than 4.0 have been demonstrated to correlate with acceptable readability in sunlight.

A theoretical relative transmission characteristic for an optimal bandpass filter for the HDSP-2353 is presented in Figure 11. Diffuse and specular reflectance values are given in Figure 12. One AR/CP glass filter that approaches the theoretical characteristic is the 12% GREEN passband, manufactured by Marks Polarized Corporation. Figures 13a, b and c present the Luminous Index, Chrominance Index and Discrimination Index calculations for the HDSP-2353/Marks 12% GREEN filter combination. The luminous contrast ratio of 5.22 gives a Luminance Index of 4.79, combined with a Chrominance Index of 1.07 produces a Discrimination Index of 4.91.

The HDSP-2353 combined with a 14% neutral density AR/CP glass filter can achieve a luminous contrast of 4.66, providing a Discrimination Index of 4.60 which is an 16% improvement over the value of 3.97 calculated for the standard green HDSP-2303 display in Application Note 1015.

Table 1 lists calculated values for luminous contrast, Luminous Index, Chrominance Index and Discrimination Index for the three HDSP-238X series devices in combination with a 14% transmission neutral density AR/CP glass filter in sunlight.

Three filter manufacturers provide AR/CP optically tinted glass filters for use with the HDSP-235X series displays in sunlight:

Manufacturer
HOYA Optics, Inc.
3400 Edison Way
Fremont, California 94538-6138
(415) 490-1880

AR/CP Glass Filter	Transmission	HP Display
HLF-608-1G Yellow-Green Bandpass	14%	HDSP-2353 Green
HLF-608-3Y Yellowish-Orange Bandpass	14%	HDSP-2351 Yellow
HLF-608-5R Reddish-Orange Bandpass	14%	HDSP-2352 HER

Hoya offers an optical coating on the backside surface as an option.

Manufacturer
Marks Polarized Corporation
25B Jefryn Blvd. West
Deer Park, New York 11729-5715
(516) 242-1300

AR/CP Glass Filter	Transmission	HP Display
MCP-0101-5-12 Yellow-Green Bandpass	12%	HDSP-2353 Green
MCP-0201-2-22 Reddish-Orange Bandpass	22%	HDSP-2352 HER
MCP-0301-8-10 Neutral Density Gray	10%	HDSP-2351/ 2352/2353 Yellow/HER/ Green

Manufacturer
Polaroid Corporation Polarizer Division
1 Upland Road
Norwood, Massachusetts 02062 -2000
(617) 577-2000

AR/CP Glass Filter	Transmission	HP Display
HNCP10 Neutral Density Gray	10%	HDSP-2351/ 2352/2353 Yellow/HER/ Green

Refer to Application Note 1029 for more information on luminous contrast and sunlight readability.

Table I. Discrimination Index Values for the HDSP-235X Series Displays with Neutral Density Gray Filter

Display Device	Time Average Luminous Intensity	Luminous Contrast	Luminance Index	Chrominance Index	Discrimination Index
HDSP-2351	680 μcd	4.66	4.46	1.94	4.86
HDSP-2352	570 μcd	4.09	4.08	6.86	7.98
HDSP-2353	680 μcd	4.66	4.46	1.14	4.60

Ambient: 107,000 lm/m² (10,000 fc) Sunlight
Filter Type: 14% Transmission, AR/CP, Neutral Density
Filter Surface Reflectance: 0.25% Specular and 0.02% Diffuse
Luminous Intensity: Data Sheet Typical × 20% Duty Factor

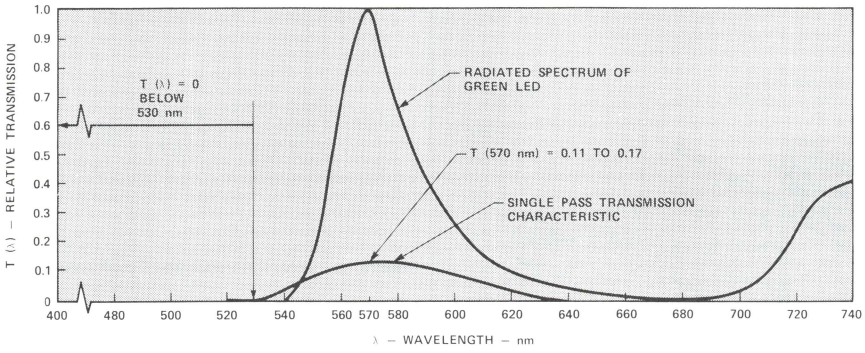


Figure 11. Relative Transmission Characteristics for a Yellow-Green Bandpass Antireflection Coated, Circular Polarized Glass Filter for use with the HDSP-2353 Green LED Alphanumeric Display.

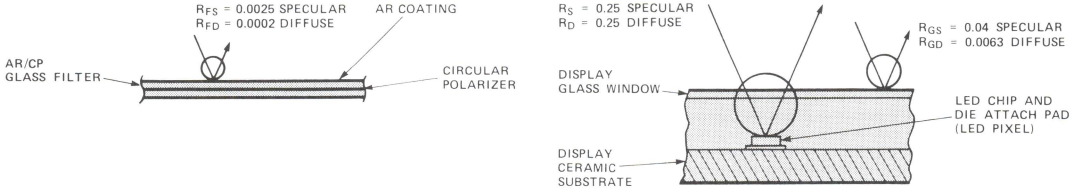


Figure 12. Reflectances off Surfaces of an HDSP-235X Series Display and an AR/CP Glass Filter.

$$ID = \sqrt{IDL^2 + IDC^2}$$

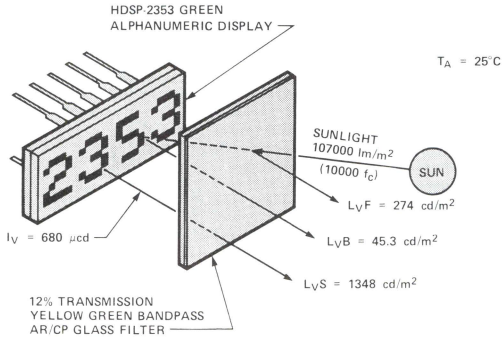
$$ID = \sqrt{(4.79)^2 + (1.07)^2}$$

$$ID = 4.91$$

$$IDL = 4.79$$

$$IDC = 1.07$$

Figure 13a. Discrimination Index for the HDSP-2353 Green LED Alphanumeric Display Combined with a 12% Transmission Yellow-Green Bandpass AR/CP Glass Filter in Indirect 107000 lm/m² (10,000 fc) sunlight.



$$CR = \frac{L_VS + L_VB + L_VF}{L_VB + L_VF}$$

$$CR = \frac{1348 + 45.3 + 274}{45.3 + 274}$$

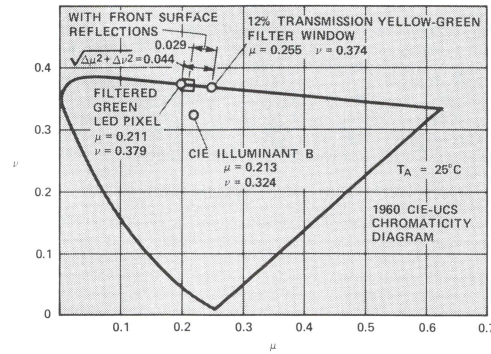
$$CR = 5.22$$

$$IDL = \frac{LOG_{10}\ CR}{0.15}$$

$$IDL = \frac{LOG_{10}\ (5.22)}{0.15}$$

$$IDL = 4.79$$

Figure 13b. Contrast Ratio and Luminance Index.



$$IDC = \frac{\sqrt{\Delta\mu^2 + \Delta\mu^2}}{0.027} = \frac{0.029}{0.027} = 1.07$$

Figure 13c. Color Difference and Chrominance Index

High Reliability Testing

Two standard reliability testing programs are available. The TXVB program is in conformance with MIL-D-87157 Quality Level A Test Tables for hermetically sealed LED displays with 100% screening tests. A TXVB product is tested to Tables I, II, IIIa, and IVa. The TXV program is an HP modification to the full conformance program and offers the 100% screening of Quality Level A, Table I, and Group A, Table II.

Part Marking System

Standard Product	With Table I and II	With Tables I, II, IIIa, IVa
HDSP-2351	HDSP-2351TXV	HDSP-2351TXVB
HDSP-2352	HDSP-2352TXV	HDSP-2352TXVB
HDSP-2353	HDSP-2353TXV	HDSP-2353TXVB

100% Screening

Table I. Quality Level A of MIL-D-87157

Test Screen	MIL-STD-750 Method	Conditions
1. Precap Visual	2072	Interpreted by HP Procedure 5956-7512-52
2. High Temperature Storage	1032	T_A = 125° C, Time = 24 hours[3]
3. Temperature Cycling	1051	Condition B, 10 cycles, 15 min. dwell
4. Constant Acceleration	2006	10,000 G's at Y_1 orientation
5. Fine Leak	1071	Condition H
6. Gross Leak	1071	Condition C
7. Interim Electrical/Optical Tests[1]	—	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL}, Visual Function and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25° C
8. Burn-In[1]	1015	Condition B at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, T_A = +85° C, LED ON-Time Duty Factor = 5%, 35 Dots On; t = 160 hours
9. Final Electrical Test[2]	—	Same as Step 7
10. Delta Determinations	—	ΔI_{CC} = ±6 mA, ΔI_{IH} (clock) = ±10 μA, ΔI_{IH} (Data In) = ±10 μA ΔI_{OH} = ±10% of initial value, and ΔI_V = -20%, T_A = 25° C
11. External Visual[1]	2009	

Notes:
1. MIL-STD-883 Test Method applies.
2. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
3. T_A = 100° C for HDSP-2353.

Table II. Group A Electrical Tests — MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25°C [1]	I_{CC} at V_B = 0.4V and 2.4V, I_{COL} at V_B = 0.4V and 2.4V, I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test.	5
Subgroup 2 DC Electrical Tests at High Temperature [1]	Same as Subgroup 1, except delete I_V and visual function, T_A = +85°C	7
Subgroup 3 DC Electrical Tests at Low Temperature [1]	Same as Subgroup 1, except delete I_V and visual function, T_A = -55°C	7
Subgroup 4, 5, and 6 not tested		
Subgroup 7 Optical and Functional Tests at 25°C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883 Method 2009	7

Note:
1. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.

Table IIIa. Group B, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/ 0 Failures
Internal Visual and Design Verification[1]	2075[6]		1 Device/ 0 Failures
Subgroup 2[2,3] Solderability	2026	T_A = 245°C for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp. Cycle)	1051	Condition B1, 15 min. Dwell	LTPD = 15
Moisture Resistance[4]	1021		
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints[5]	—	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25°C	
Subgroup 4 Operating Life Test (340 hrs.)	1027	T_A = +85°C at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, LED ON-Time Duty Factor = 5%, 35 Dots On	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	
Subgroup 5 Non-operating (Storage) Life Test (340 hrs.)	1032	T_A = +125°C[6]	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	

Notes:
1. Visual inspection is performed throught the display window.
2. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
3. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
4. Initial conditioning is a 15° inward bend for one cycle.
5. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
6. Equivalent to MIL-STD-883, Method 2014.

Table IVa. Group C, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Physical Dimensions	2066		2 Devices/ 0 Failures
Subgroup 2[2]			
Lead Integrity[7, 9]	2004	Condition B2	LTPD = 15
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G, Time = 0.5 ms, 5 blows in each orientation X_1, Y_1, Z_1	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G at Y_1 orientation	
External Visual[4]	1010 or 1011		
Electrical/Optical Endpoints[8]	—	I_{CC} (at V_B = 0.4V and 2.4V) I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In) I_{IL} (V_B, Clock and Data In) I_{OH}, I_{OL}, Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25°C.	
Subgroup 4[1,3]			
Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		
Subgroup 5			
Bond Strength[5]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			
Operating Life Test[6]	1026	T_A = +85°C at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, 35 Dots On	λ = 10
Electrical/Optical Endpoints[8]	—	Same as Subgroup 3	

Notes:

1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. If a given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1000 hours in order to satisfy the Group C life test requirements. In such cases, either the 340 hour endpoint measurements shall be made a basis for Group B lot acceptance or the 1000 hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.
7. MIL-STD-883 test method applies.
8. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
9. Initial conditioning is a 15 degree inward bend, 3 cycles.

HEWLETT PACKARD

HERMETIC, EXTENDED TEMPERATURE RANGE 5.0mm (.20") 5x7 ALPHANUMERIC DISPLAYS

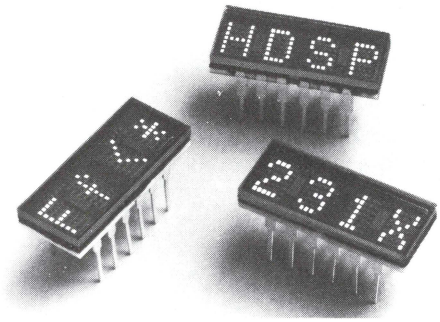
STANDARD RED	HDSP-2310/2310TXV/2310TXVB
YELLOW	HDSP-2311/2311TXV/2311TXVB
HIGH EFFICIENCY RED	HDSP-2312/2312TXV/2312TXVB
HIGH PERFORMANCE GREEN	HDSP-2313/2313TXV/2313TXVB

Features

- **WIDE OPERATING TEMPERATURE RANGE -55°C TO +85°C**
- **TRUE HERMETIC PACKAGE FOR RED, YELLOW AND HIGH EFFICIENCY RED DISPLAYS[1]**
- **TXVB VERSION CONFORMS TO MIL-D-87157 QUALITY LEVEL A TEST TABLES**
- **FOUR COLORS**
  Standard Red **Yellow**
  High Efficiency Red **High Performance Green**
- **CATEGORIZED FOR LUMINOUS INTENSITY**
- **YELLOW AND GREEN DISPLAYS CATEGORIZED FOR COLOR**
- **INTEGRATED SHIFT REGISTERS WITH CONSTANT CURRENT LED DRIVERS**
- **5x7 LED MATRIX DISPLAYS FULL ASCII CHARACTER SET**
- **WIDE VIEWING ANGLE**
- **END STACKABLE**
- **TTL COMPATIBLE**

Note:

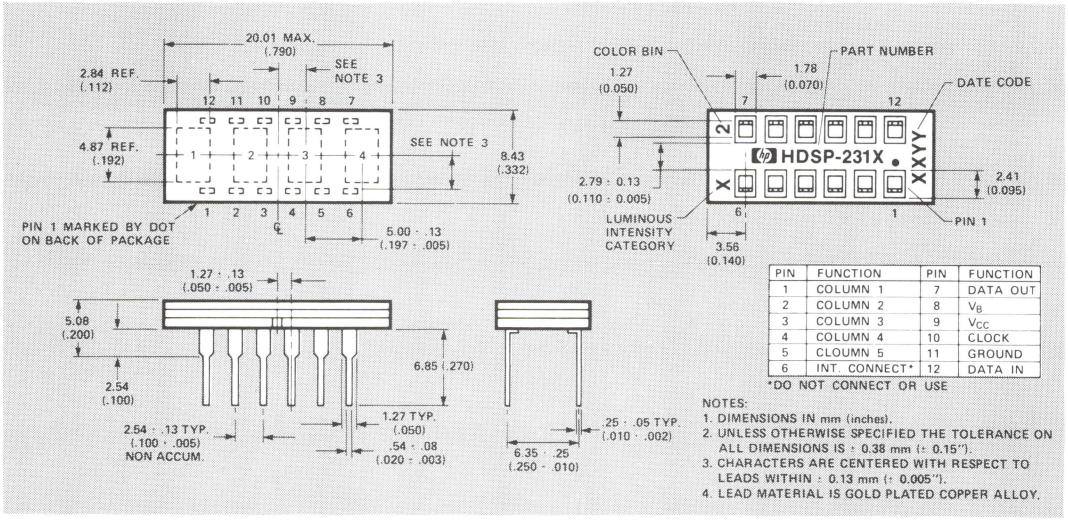
1. The HDSP-2313 high performance green displays are epoxy sealed and conform to MIL-D-87157 hermeticity requirements.



Description

The HDSP-2310 series displays are 5.0 mm (0.20 in.) 5x7 LED arrays for display of alphanumeric information. These devices are available in standard red, yellow, high efficiency red and high performance green. All displays use a 14 pin dual-in-line glass ceramic package. The hermetic HDSP-2310/-2311/-2312 displays utilize a solder-glass seal. The HDSP-2313 displays utilize an epoxy glass-to-ceramic seal. All display packages conform to the hermeticity requirements of MIL-D-87157. An on-board SIPO (Serial-In-Parallel-Out) 7-bit shift register associated with each digit controls constant current LED row drivers. Full character display is achieved by external column strobing.

Package Dimensions



PIN	FUNCTION	PIN	FUNCTION
1	COLUMN 1	7	DATA OUT
2	COLUMN 2	8	V_B
3	COLUMN 3	9	V_{CC}
4	COLUMN 4	10	CLOCK
5	CLOUMN 5	11	GROUND
6	INT. CONNECT*	12	DATA IN

*DO NOT CONNECT OR USE

NOTES:
1. DIMENSIONS IN mm (inches).
2. UNLESS OTHERWISE SPECIFIED THE TOLERANCE ON ALL DIMENSIONS IS ± 0.38 mm (± 0.15").
3. CHARACTERS ARE CENTERED WITH RESPECT TO LEADS WITHIN ± 0.13 mm (± 0.005").
4. LEAD MATERIAL IS GOLD PLATED COPPER ALLOY.

Typical Applications

- **MILITARY EQUIPMENT**
- **AVIONICS**
- **HIGH RELIABILITY INDUSTRIAL EQUIPMENT**

Absolute Maximum Ratings (HDSP-2310/-2311/-2312/-2313)

Supply Voltage V_{CC} to Ground ..... —0.5V to 6.0V
Inputs, Data Out and V_B ..... —0.5V to V_{CC}
Column Input Voltage, V_{COL} ..... —0.5V to +6.0V
Free Air Operating
Temperature Range, T_A [1,2] ..... —55°C to +85°C

Storage Temperature Range, T_S
HDSP-2310/-2311/-2312 ..... -65°C to +125°C
HDSP-2313 ..... -55°C to +100°C
Maximum Allowable Power Dissipation
at $T_A = 25°C$[1,2,3] ..... 1.46 Watts
Maximum Solder Temperature 1.59 mm (.063")
Below Seating Plane t < 5 secs ..... 260°C

Recommended Operating Conditions (HDSP-2310/-2311/-2312/-2313)

Parameter	Symbol	Min.	Nom.	Max.	Units	Fig.
Supply Voltage	V_{CC}	4.75	5.0	5.25	V	
Data Out Current, Low State	I_{OL}			1.6	mA	
Data Out Current, High State	I_{OH}			-0.5	mA	
Column Input Voltage, Column On HDSP-2310	V_{COL}	2.4		3.5	V	4
Column Input Voltage, Column On HDSP-2311/-2312/-2313	V_{COL}	2.75		3.5	V	4
Setup Time	t_{setup}	70	45		ns	1
Hold Time	t_{hold}	30	0		ns	1
Width of Clock	$t_{w(Clock)}$	75			ns	1
Clock Frequency	f_{clock}	0		3	MHz	1
Clock Transition Time	t_{THL}			200	ns	1
Free Air Operating Temperature Range [1,2]	T_A	-55		85	°C	

Electrical Characteristics Over Operating Temperature Range

(Unless otherwise specified)

Description		Symbol	Test Conditions		Min.	Typ.*	Max.	Units	Fig.
Supply Current		I_{CC}	$V_{CC} = 5.25V$, $V_{CLOCK} = V_{DATA} = 2.4V$, All SR Stages = Logical 1	$V_B = 0.4V$		45	60	mA	
				$V_B = 2.4V$		73	95	mA	
Column Current at any Column Input		I_{COL}	$V_{CC} = 5.25V$, $V_{COL} = 3.5V$	$V_B = 0.4V$			500	μA	4
Column Current at any Column Input		I_{COL}	All SR Stages = Logical 1	$V_B = 2.4V$		380	520	mA	
V_B, Clock or Data Input Threshold High		V_{IH}	$V_{CC} = 4.75V$		2.0			V	
V_B, Data Input Threshold Low		V_{IL}					0.8	V	
Clock Input Threshold Low		V_{IL}					0.6	V	
Input Current Logical 1	V_B, Clock	I_{IH}	$V_{CC} = 5.25V$, $V_{IH} = 2.4V$			20	80	μA	
	Data In	I_{IH}				10	40	μA	
Input Current Logical 0	V_B, Clock	I_{IL}	$V_{CC} = 5.25V$, $V_{IL} = 0.4V$			-500	-800	μA	
	Data In	I_{IL}				-250	-400	μA	
Data Out Voltage		V_{OH}	$V_{CC} = 4.75V$, $I_{OH} = -0.5$ mA, $I_{COL} = 0$ mA		2.4	3.4		V	
		V_{OL}	$V_{CC} = 4.75V$, = 1.6 mA, $I_{COL} = 0$ mA			0.2	0.4	V	
Power Dissipation Per Package**		P_D	$V_{CC} = 5.0V$, $V_{COL} = 3.5V$, 17.5% DF, 15 LEDs on per character, $V_B = 2.4V$			0.78		W	2
Thermal Resistance IC Junction-to-Case		$R\theta_{J-C}$				25		°C/W/ Device	2
Leak Rate							$5x10^{-8}$	cc/sec	

*All typical values specified at $V_{CC} = 5.0V$ and $T_A = 25°C$ unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

1. Operation above 85°C ambient is possible provided the IC junction temperature, T_J, does not exceed 125°C.
2. The device should be derated linearly above 37°C at 16.7 mW/°C. This derating is based on a device mounted in a socket having a thermal resistance from case to ambient at 35°C/W per device. See Figure 2 for power deratings based on a lower thermal resistance.
3. Maximum allowable dissipation is derived from $V_{CC} = 5.25V$, $V_B = 2.4V$, $V_{COL} = 3.5V$ 20 LEDs on per character, 20% DF.

Optical Characteristics

STANDARD RED HDSP-2310

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED [4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25°C[6], V_B = 2.4V	220	370		μcd	3
Peak Wavelength	λ_{PEAK}			655		nm	
Dominant Wavelength[7]	λ_d			639		nm	

YELLOW HDSP-2311

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED [4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25°C[6], V_B = 2.4V	650	1140		μcd	3
Peak Wavelength	λ_{PEAK}			583		nm	
Dominant Wavelength[5,7]	λ_d			585		nm	

HIGH EFFICIENCY RED HDSP-2312

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED [4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25°C[6], V_B = 2.4V	650	1430		μcd	3
Peak Wavelength	λ_{PEAK}			635		nm	
Dominant Wavelength[7]	λ_d			626		nm	

HIGH PERFORMANCE GREEN HDSP-2313

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED [4,8] (Character Average)	I_{VPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25°C[6], V_B = 2.4V	1280	2410		μcd	6
Peak Wavelength	λ_{PEAK}			568		nm	
Dominant Wavelength[5,7]	λ_d			574		nm	

*All typical values specified at V_{CC} = 5.0V and T_A = 25°C unless otherwise noted.

Notes:

4. The characters are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
5. The HDSP-2311 and HDSP-2313 are categorized for color with the color category designated by a number code on the bottom of the package.
6. The luminous intensity is measured at $T_A = T_j$ = 25°C. No time is allowed for the device to warm-up prior to measurement.

**Power dissipation per package with four characters illuminated.

7. Dominant wavelength λ_d, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
8. The luminous sterance of the LED may be calculated using the following relationships:

L_V (cd/m²) = I_V (Candela)/A (Metre)²
L_V (Footlamberts) = πI_V = (Candela)/A (Foot)²
A = 5.3 x 10^{-8} M² = 5.8 x 10^{-7} (Foot)²

Electrical Description

The HDSP-2310 series of four character alphanumeric displays have been designed to allow the user maximum flexibility in interface electronics design. Each four character module is arranged as a 28 bit serial in parallel out shift register as is shown in Figure 5. The display module features Data In and Data Out terminals arrayed for easy PC board interconnection. Data Out represents the output of the 7th bit of digit number 4 shift register. Shift register clocking occurs on the high to low transition of the Clock input. The like columns of each character in a display cluster are tied to a single pin. Figure 5 is the block diagram for the displays. High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5x7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduction in power consumption.

In the normal mode of operation, input data for digit 4, column 1 is loaded into the 7 on-board shift register locations 1 through 7. Column 1 data for digits 3, 2, and 1 is similarly shifted into the display shift register locations. The column 1 input is now enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4 and 5. If the time necessary to decode and load data into the shift register is t, then with 5 columns, each column of the display is operating at a duty factor of:

$$D.F. = \frac{T}{5(t+T)}$$

The time frame, t + T, alloted to each column of the display is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

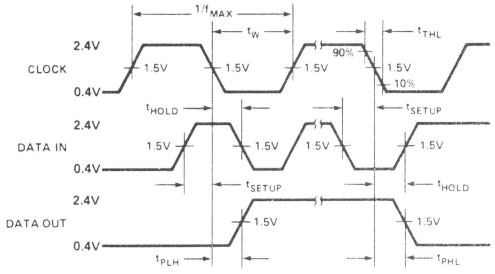
With five columns to be addressed, this refresh rate then gives a value for the time t + T of:

$$1/[5 \times (100)] = 2 \text{ msec}$$

If the device is operated at 3.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

The ESD susceptibility of these devices is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263.

For further applications information, refer to HP Application Note 1016.



Parameter	Condition	Min.	Typ.	Max.	Units
f_{clock} CLOCK Rate				3	MHz
t_{PLH}, t_{PHL} Propagation delay CLOCK to DATA OUT	C_L = 15pF R_L=2.4KΩ			125	ns

Figure 1. Switching Characteristics HDSP-2310/-2311/-2312/-2313 (T_A = -55°C to +85°C)

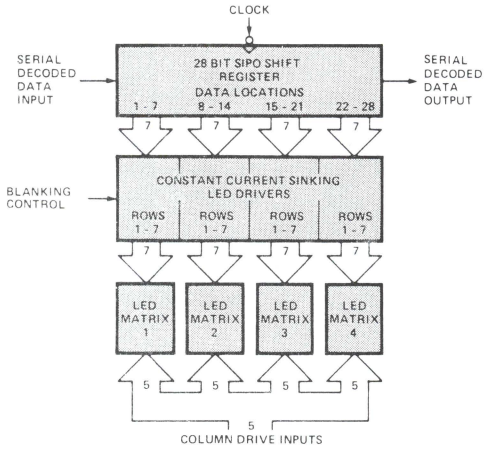


Figure 5. Block Diagram of HDSP-2310/-2311/-2312/-2313

Mechanical and Thermal Considerations

The HDSP-2310 series displays are available in standard ceramic dual-in-line packages. They are designed for plugging into sockets or soldering into PC boards. The packages may be horizontally or vertically stacked for character arrays of any desired size. HDSP-2310 series displays utilize a high output current IC to provide excellent readability in bright ambient lighting. Full power operation (V_{CC} = 5.25V, V_B = 2.4V, V_{COL} = 3.5V) with worst case thermal resistance from IC junction to ambient of 60° C/watt/device is possible up to ambient temperature of 37° C. For operation above 37° C, the maximum device dissipation should be derated linearly at 16.7 mW/° C (see Figure 2). With an improved thermal design, operation at higher ambient temperatures without derating is possible.

Power derating for this family of displays can be achieved in several ways. The power supply voltage can be lowered to a minimum of 4.75V. Column Input Voltage, V_{COL}, can be decreased to the recommended minimum values of 2.4V for the HDSP-2310 and 2.75V for the HDSP-2311/-2312/-2313. Also, the average drive current can be decreased through pulse width modulation of V_B.

The HDSP-2310 series displays have integral glass windows. A front panel contrast enhancement filter is desirable in most actual display applications. Some suggested filter materials are provided in Figure 6. Additional information on filtering and contrast enhancement can be found in HP Application Note 1015.

Post solder cleaning may be accomplished using water or Freon/alcohol mixtures formulated for vapor cleaning processing or Freon/alcohol mixtures formulated for room temperature cleaning. Freon/alcohol vapor cleaning processing for up to 2 minutes in vapors at boiling is permissible. Suggested solvents include Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15, and water.

High Reliability Testing

Two standard reliability testing programs are available. The TXVB program is in conformance with Quality Level A of MIL-D-87157 for hermetically sealed LED displays with 100% screening tests. A TXVB product is tested to Tables I, II, IIIa, and IVa. The TXV program is an HP modification to the full conformance program and offers the 100% screening of Quality Level A, Table I, and Group A, Table II.

Part Marking System

Standard Product	With Table I and II	With Tables I, II, IIIa, IVa
HDSP-2310	HDSP-2310TXV	HDSP-2310TXVB
HDSP-2311	HDSP-2311TXV	HDSP-2311TXVB
HDSP-2312	HDSP-2312TXV	HDSP-2312TXVB
HDSP-2313	HDSP-2313TXV	HDSP-2313TXVB

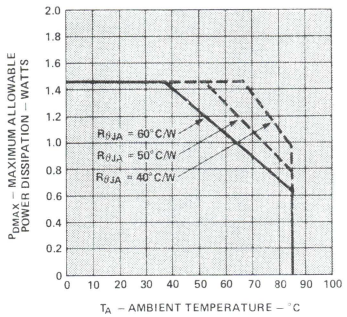


Figure 2. Maximum Allowable Power Dissipation vs. Temperature

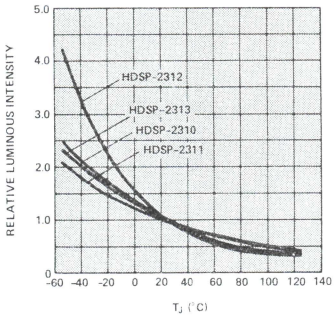


Figure 3. Relative Luminous Intensity vs. Temperature

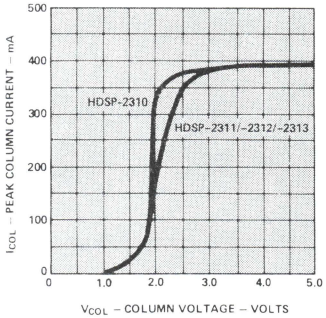


Figure 4. Peak Column Current vs. Column Voltage

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
HDSP-2310 Standard Red	Panelgraphic Dark Red 63 Ruby Red 60 Chequers Red 118 Plexiglass 2423	Polaroid HNCP 37 3M Light Control Film Panelgraphic Gray 10	
HDSP-2311 Yellow	Panelgraphic Yellow 27 Chequers Amber 107	Chequers Grey 105	Polaroid Gray HNCP10 HOYA Yellowish-Orange HLF-608-3Y Marks Gray MCP-0301-8-10
HDSP-2312 HER	Panelgraphic Ruby Red 60 Chequers Red 112		Polaroid Gray HNCP10 HOYA Reddish-Orange HLF-608-5R Marks Gray MCP-0301-8-10 Marks Reddish-Orange MCP-0201-2-22
HDSP-2313 HP Green	Panelgraphic Green 48 Chequers Green 107		Polaroid Gray HNCP10 HOYA Yellow-Green HLF-608-1G Marks Yellow-Green MCP-0101-5-12

Figure 6. Contrast Enhancement Filters

100% Screening

Table I. Quality Level A of MIL-D-87157

Test Screen	MIL-STD-750 Method	Conditions
1. Precap Visual	2072	Interpreted by HP Procedure 5956-7512-52
2. High Temperature Storage	1032	T_A = 125° C, Time = 24 hours[3]
3. Temperature Cycling	1051	Condition B, 10 cycles, 15 min. dwell
4. Constant Acceleration	2006	10,000 G's at Y_1 orientation
5. Fine Leak	1071	Condition H
6. Gross Leak	1071	Condition C
7. Interim Electrical/Optical Tests[1]	—	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25° C
8. Burn-In[1]	1015	Condition B at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, T_A = +85° C, LED ON-Time Duty Factor = 5%, 35 Dots On; t = 160 hours
9. Final Electrical Test[2]	—	Same as Step 7
10. Delta Determinations	—	ΔI_{CC} = ±6 mA, ΔI_{IH} (clock) = ±10 μA, ΔI_{IH} (Data In) = ±10 μA ΔI_{OH} = ±10% of initial value, and ΔI_V = -20%, T_A = 25° C
11. External Visual[1]	2009	

Notes:
1. MIL-STD-883 Test Method applies.
2. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
3. T_A = 100° C for HDSP-2313.

Table II. Group A Electrical Tests — MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25°C[1]	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test.	5
Subgroup 2 DC Electrical Tests at High Temperature[1]	Same as Subgroup 1, except delete I_V and visual function, T_A = +85°C	7
Subgroup 3 DC Electrical Tests at Low Temperature[1]	Same as Subgroup 1, except delete I_V and visual function, T_A = -55°C	7
Subgroup 4, 5, and 6 not tested		
Subgroup 7 Optical and Functional Tests at 25°C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883 Method 2009	7

Note:
1. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.

Table IIIa. Group B, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/ 0 Failures
Internal Visual Design Verification[1]	2075[7]		1 Device/ 0 Failures
Subgroup 2[2,3] Solderability	2026	T_A = 245°C for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp. Cycle)	1051	Condition B1, 15 min. Dwell	LTPD = 15
Moisture Resistance[4]	1021		
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints[5]	—	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25°C	
Subgroup 4 Operating Life Test (340 hrs.)	1027	T_A = +85°C at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, LED ON-Time Duty Factor = 5%, 35 Dots On	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	
Subgroup 5 Non-operating (Storage) Life Test (340 hrs.)	1032	T_A = +125°C[6]	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	

Notes:
1. Visual inspection is performed through the display window.
2. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
3. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
4. Initial conditioning is a 15° inward bend for one cycle.
5. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
6. T_A = 100°C for HDSP-2313.
7. Equivalent to MIL-STD-883, Method 2014.

Table IVa. Group C, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Physical Dimensions	2066		2 Devices/ 0 Failures
Subgroup 2[2]			
Lead Integrity[7, 9]	2004	Condition B2	LTPD = 15
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G, Time = 0.5 ms, 5 blows in each orientation X_1, Y_1, Z_1	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G at Y_1 orientation	
External Visual[4]	1010 or 1011		
Electrical/Optical Endpoints[8]	—	I_{CC} (at V_B = 0.4V and 2.4V) I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In) I_{IL} (V_B, Clock and Data In) I_{OH}, I_{OL}, Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25°C.	
Subgroup 4[1,3]			
Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		
Subgroup 5			
Bond Strength[5]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			
Operating Life Test[6]	1026	T_A = +85°C at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, 35 Dots On	λ = 10
Electrical/Optical Endpoints[8]	—	Same as Subgroup 3	

Notes:

1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. If a given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1000 hours in order to satisfy the Group C life test requirements. In such cases, either the 340 hour endpoint measurements shall be made a basis for Group B lot acceptance or the 1000 hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.
7. MIL-STD-883 test method applies.
8. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
9. Initial conditioning is a 15 degree inward bend, 3 cycles.

HEWLETT PACKARD

HERMETIC, EXTENDED TEMPERATURE RANGE 6.9mm (.27") 5x7 ALPHANUMERIC DISPLAYS

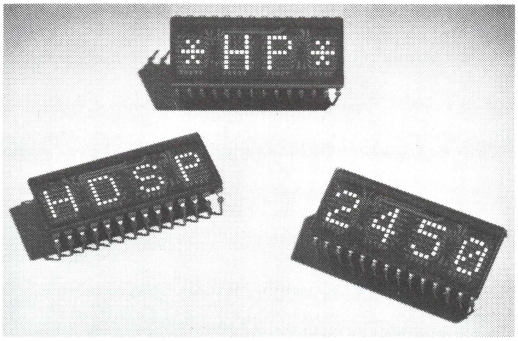
STANDARD RED	HDSP-2450/2450TXV/2450TXVB
YELLOW	HDSP-2451/2451TXV/2451TXVB
HIGH EFFICIENCY RED	HDSP-2452/2452TXV/2452TXVB
HIGH PERFORMANCE GREEN	HDSP-2453/2453TXV/2453TXVB

Features

- WIDE OPERATING TEMPERATURE RANGE -55°C TO +85°C
- TRUE HERMETIC PACKAGE FOR RED, YELLOW AND HIGH EFFICIENCY RED DISPLAYS[1]
- TXVB VERSIONS CONFORM TO MIL-D-87157 QUALITY LEVEL A TEST TABLES
- FOUR COLORS
  Standard Red — Yellow
  High Efficiency Red — High Performance Green
- CATEGORIZED FOR LUMINOUS INTENSITY
- YELLOW AND GREEN DISPLAYS CATEGORIZED FOR COLOR
- INTEGRATED SHIFT REGISTERS WITH CONSTANT CURRENT DRIVERS
- 5x7 LED MATRIX DISPLAYS FULL ASCII CHARACTER SET
- WIDE VIEWING ANGLE
- END STACKABLE
- TTL COMPATIBLE

Note:

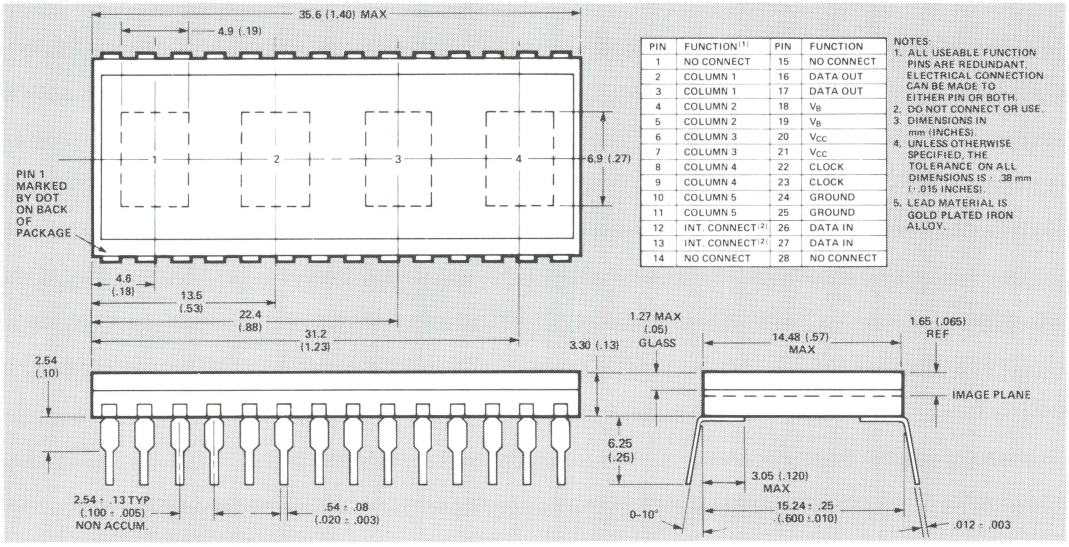
1. The HDSP-2453 is epoxy sealed and complies with MIL-D-87157 hermeticity requirements.



Description

The HDSP-2450 series displays are 6.9 mm (0.27 in.) 5x7 LED arrays for display of alphanumeric information. These devices are available in standard red, yellow, high efficiency red and high performance green. All displays use a 28 pin dual-in-line glass ceramic package. The hermetic HDSP-2450/-2451/-2452 displays utilize a solder-glass seal. The HDSP-2453 displays utilize an epoxy glass-to-ceramic seal. All display packages conform to the hermeticity requirements of MIL-D-87157. An on-board SIPO (Serial-In-Parallel-Out) 7-bit shift register associated with each digit controls constant current LED row drivers. Full character display is achieved by external column strobing.

Package Dimensions



PIN	FUNCTION[1]	PIN	FUNCTION
1	NO CONNECT	15	NO CONNECT
2	COLUMN 1	16	DATA OUT
3	COLUMN 1	17	DATA OUT
4	COLUMN 2	18	V_B
5	COLUMN 2	19	V_B
6	COLUMN 3	20	V_{CC}
7	COLUMN 3	21	V_{CC}
8	COLUMN 4	22	CLOCK
9	COLUMN 4	23	CLOCK
10	COLUMN 5	24	GROUND
11	COLUMN 5	25	GROUND
12	INT. CONNECT[2]	26	DATA IN
13	INT. CONNECT[2]	27	DATA IN
14	NO CONNECT	28	NO CONNECT

NOTES:
1. ALL USEABLE FUNCTION PINS ARE REDUNDANT. ELECTRICAL CONNECTION CAN BE MADE TO EITHER PIN OR BOTH.
2. DO NOT CONNECT OR USE.
3. DIMENSIONS IN mm (INCHES).
4. UNLESS OTHERWISE SPECIFIED, THE TOLERANCE ON ALL DIMENSIONS IS ± .38 mm (± .015 INCHES).
5. LEAD MATERIAL IS GOLD PLATED IRON ALLOY.

Typical Applications

- **MILITARY EQUIPMENT**
- **AVIONICS**
- **HIGH RELIABILITY INDUSTRIAL EQUIPMENT**

Absolute Maximum Ratings (HDSP-2450/-2451/-2452/-2453)

Supply Voltage V_{CC} to Ground ..... —0.5V to 6.0V
Inputs, Data Out and V_B ..... —0.5V to V_{CC}
Column Input Voltage, V_{COL} ..... —0.5V to +6.0V
Free Air Operating
Temperature Range, T_A [1,2] ..... —55°C to +85°C

Storage Temperature Range, T_S
HDSP-2450/-2451/-2452 ..... -65°C to +125°C
HDSP-2453 ..... -55°C to +100°C
Maximum Allowable Power Dissipation
at $T_A = 25°C$[1,2,3] ..... 1.46 Watts
Maximum Solder Temperature 1.59 mm (.063")
Below Seating Plane t < 5 secs ..... 260°C

Recommended Operating Conditions (HDSP-2450/-2451/-2452/-2453)

Parameter	Symbol	Min.	Nom.	Max.	Units	Fig.
Supply Voltage	V_{CC}	4.75	5.0	5.25	V	
Data Out Current, Low State	I_{OL}			1.6	mA	
Data Out Current, High State	I_{OH}			-0.5	mA	
Column Input Voltage, Column On HDSP-2450	V_{COL}	2.4		3.5	V	4
Column Input Voltage, Column On HDSP-2451/2452/2453	V_{COL}	2.75		3.5	V	4
Setup Time	t_{setup}	70	45		ns	1
Hold Time	t_{hold}	30	0		ns	1
Width of Clock	$t_{W(Clock)}$	75			ns	1
Clock Frequency	f_{clock}	0		3	MHz	1
Clock Transition Time	t_{THL}			200	ns	1
Free Air Operating Temperature Range [1,2]	T_A	-55		85	°C	

Electrical Characteristics Over Operating Temperature Range

(Unless otherwise specified)

Description		Symbol	Test Conditions		Min.	Typ.*	Max.	Units	Fig.
Supply Current		I_{CC}	$V_{CC} = 5.25V$, $V_{CLOCK} = V_{DATA} = 2.4V$, All SR Stages = Logical 1	$V_B = 0.4V$		45	60	mA	
				$V_B = 2.4V$		73	95	mA	
Column Current at any Column Input		I_{COL}	$V_{CC} = 5.25$ V, $V_{COL} = 3.5V$	$V_B = 0.4V$			500	μA	4
Column Current at any Column Input		I_{COL}	All SR Stages = Logical 1	$V_B = 2.4V$		380	520	mA	
V_B, Clock or Data Input Threshold High		V_{IH}	$V_{CC} = 4.75V$		2.0			V	
V_B, Data Input Threshold Low		V_{IL}					0.8	V	
Clock Input Threshold Low		V_{IL}					0.6	V	
Input Current Logical 1	V_B, Clock	I_{IH}	$V_{CC} = 5.25V$, $V_{IH} = 2.4V$			20	80	μA	
	Data In	I_{IH}				10	40	μA	
Input Current Logical 0	V_B, Clock	I_{IL}	$V_{CC} = 5.25V$, $V_{IL} = 0.4V$			-500	-800	μA	
	Data In	I_{IL}				-250	-400	μA	
Data Out Voltage		V_{OH}	$V_{CC} = 4.75V$, $I_{OH} = -0.5$ mA, $I_{COL} = 0$ mA		2.4	3.4		V	
		V_{OL}	$V_{CC} = 4.75V$ $I_{OL} = 1.6$ mA, $I_{COL} = 0$ mA			0.2	0.4	V	
Power Dissipation Per Package**		P_D	$V_{CC} = 5.0V$, $V_{COL} = 3.5V$, 17.5% DF, 15 LEDs on per character, $V_B = 2.4V$			0.78		W	2
Thermal Resistance IC Junction-to-Case		$R\theta_{J-C}$				20		°C/W/ Device	2
Leak Rate							$5x10^{-8}$	cc/sec	

*All typical values specified at $V_{CC} = 5.0V$ and $T_A = 25°C$ unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

1. Operation above 85°C ambient is possible provided the IC junction temperature, T_J, does not exceed 125°C.
2. The device should be derated linearly above 60°C at 22.2 mW/°C. This derating is based on a device mounted in a socket having a thermal resistance from case to ambient at 25°C/W per device. See Figure 2 for power deratings based on a lower thermal resistance.
3. Maximum allowable dissipation is derived from $V_{CC} = 5.25V$, $V_B = 2.4V$, $V_{COL} = 3.5V$ 20 LEDs on per character, 20% DF.

Optical Characteristics (continued)

STANDARD RED HDSP-2450

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{vPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	220	370		µcd	3
Peak Wavelength	λ_{PEAK}			655		nm	
Dominant Wavelength[7]	λ_d			639		nm	

YELLOW HDSP-2451

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{vPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	850	1400		µcd	3
Peak Wavelength	λ_{PEAK}			583		nm	
Dominant Wavelength[5,7]	λ_d			585		nm	

HIGH EFFICIENCY RED HDSP-2452

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{vPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	850	1530		µcd	3
Peak Wavelength	λ_{PEAK}			635		nm	
Dominant Wavelength[7]	λ_d			626		nm	

HIGH PERFORMANCE GREEN HDSP-2453

Description	Symbol	Test Conditions	Min.	Typ.*	Max.	Units	Fig.
Peak Luminous Intensity per LED[4,8] (Character Average)	I_{vPeak}	V_{CC} = 5.0V, V_{COL} = 3.5V T_j = 25° C[6], V_B = 2.4V	1280	2410		µcd	3
Peak Wavelength	λ_{PEAK}			568		nm	
Dominant Wavelength[7]	λ_d			574		nm	

*All typical values specified at V_{CC} = 5.0V and T_A = 25° C unless otherwise noted.

**Power dissipation per package with four characters illuminated.

Notes:

4. The characters are categorized for luminous intensity with the intensity category designated by a letter code on the bottom of the package.
5. The HDSP-2451 and HDSP-2453 are categorized for color with the color category designated by a number code on the bottom of the package.
6. The luminous intensity is measured at $T_A = T_j$ = 25° C. No time is allowed for the device to warm-up prior to measurement.
7. Dominant wavelength λ_d, is derived from the CIE chromaticity diagram, and represents the single wavelength which defines the color of the device.
8. The luminous sterance of the LED may be calculated using the following relationships:
   L_v (cd/m²) = I_v (Candela)/A (Metre)²
   L_v (Footlamberts) = πI_v (Candela)/A (Foot)²
   A = 5.3 x 10^{-8} M² = 5.8 x 10^{-7} Foot²

Electrical Description

The HDSP-2450 series of four character alphanumeric displays have been designed to allow the user maximum flexibility in interface electronics design. Each four character display module features Data In and Data Out terminals arrayed for easy PC board interconnection. Data Out represents the output of the 7th bit of digit number 4 shift register. Shift register clocking occurs on the high to low transition of the Clock input. The like columns of each character in a display cluster are tied to a single pin. Figure 5 is the block diagram for the displays. High true data in the shift register enables the output current mirror driver stage associated with each row of LEDs in the 5x7 diode array.

The TTL compatible V_B input may either be tied to V_{CC} for maximum display intensity or pulse width modulated to achieve intensity control and reduction in power consumption.

The normal mode of operation input data for digit 4, column 1 is loaded into the 7 on-board shift register locations 1 through 7. Column 1 data for digits 3, 2, and 1 is similarly shifted into the display shift register locations. The column 1 input is now enabled for an appropriate period of time, T. A similar process is repeated for columns 2, 3, 4 and 5. If the time necessary to decode and load data into the shift register is t, then with 5 columns, each column of the display is operating at a duty factor of:

$$D.F. = \frac{T}{5\,(t+T)}$$

The time frame, t + T, alloted to each column of the display is generally chosen to provide the maximum duty factor consistent with the minimum refresh rate necessary to achieve a flicker free display. For most strobed display systems, each column of the display should be refreshed (turned on) at a minimum rate of 100 times per second.

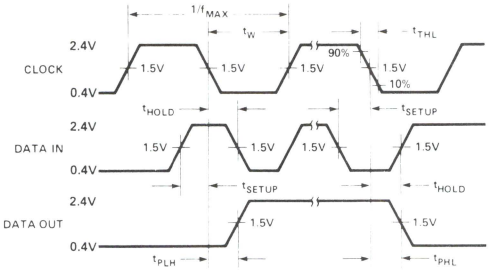
With columns to be addressed, this refresh rate then gives a value for the time t + T of:

$$1/[5 \times (100)] = 2 \text{ msec}$$

If the device is operated at 3.0 MHz clock rate maximum, it is possible to maintain t<<T. For short display strings, the duty factor will then approach 20%.

The ESD susceptibility of these devices is Class A of MIL-STD-883 or Class 2 of DOD-STD-1686 and DOD-HDBK-263.

For further applications information, refer to HP Application Note 1016.



Parameter	Condition	Min.	Typ.	Max.	Units
f_{clock} CLOCK Rate				3	MHz
t_{PLH}, t_{PHL} Propagation delay CLOCK to DATA OUT	C_L = 15pF R_L=2.4KΩ			125	ns

Figure 1. Switching Characteristics HDSP-2450/-2451/-2452/-2453 (T_A = -55°C to +85°C)

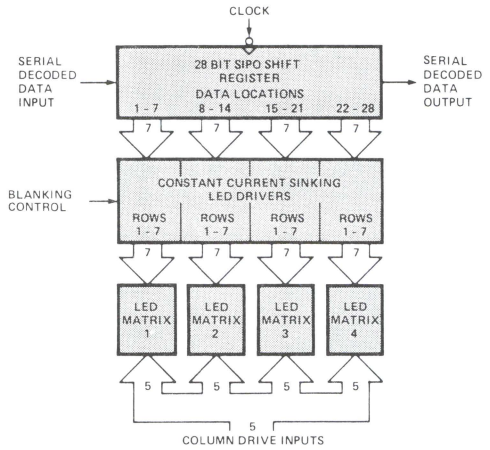


Figure 5. Block Diagram of HDSP-2450/-2451/-2452/-2453

Mechanical and Thermal Considerations

The HDSP-245X series displays are available in standard ceramic dual-in-line packages. They are designed for plugging into sockets or soldering into PC boards. The packages may be horizontally or vertically stacked for character arrays of any desired size. HDSP-245X series displays utilize a high output current IC to provide excellent readability in bright ambient lighting. Full power operation (V_{CC} = 5.25V, V_B = 2.4V, V_{COL} = 3.5V) with worst case thermal resistance from IC junction to ambient of 45° C/watt/device is possible up to ambient temperature of 60° C. For operation above 60° C, the maximum device dissipation should be derated linearly at 22.2 mW/° C (see Figure 2). With an improved thermal design, operation at higher ambient temperatures without derating is possible.

Power derating for this family of displays can be achieved in several ways. The power supply voltage can be lowered to a minimum of 4.75V. Column Input Voltage, V_{COL}, can be decreased to the recommended minimum values of 2.4V for the HDSP-2450 and 2.75V for the HDSP-2451/-2452/-2453. Also, the average drive current can be decreased through pulse width modulation of V_B.

The HDSP-245X series displays have glass windows. A front panel contrast enhancement filter is desirable in most actual display applications. Some suggested filter materials are provided in Figure 6. Additional information on filtering and contrast enhancement can be found in HP Application Note 1015.

Post solder cleaning may be accomplished using water or Freon/alcohol mixtures formulated for vapor cleaning processing or Freon/alcohol mixtures formulated for room temperature cleaning. Freon/alcohol vapor cleaning processing for up to 2 minutes in vapors at boiling is permissible. Suggested solvents include Freon TF, Freon TE, Genesolv DI-15, Genesolv DE-15, and water.

High Reliability Testing

Two standard reliability testing programs are available. The TXVB program is in conformance with Quality Level A of MIL-D-87157 for hermetically sealed LED displays with 100% screening tests. A TXVB product is tested to Tables I, II, IIIa, and IVa. The TXV program is an HP modification to the full conformance program and offers the 100% screening of Quality Level A, Table I, and Group A, Table II.

Part Marking System

Standard Product	With Table I and II	With Tables I, II, IIIa, IVa
HDSP-2450	HDSP-2450TXV	HDSP-2450TXVB
HDSP-2451	HDSP-2451TXV	HDSP-2451TXVB
HDSP-2452	HDSP-2452TXV	HDSP-2452TXVB
HDSP-2453	HDSP-2453TXV	HDSP-2453TXVB

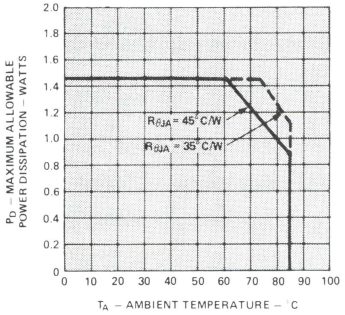


Figure 2. Maximum Allowable Power Dissipation vs. Temperature

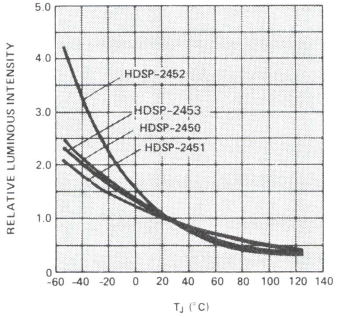


Figure 3. Relative Luminous Intensity vs. Temperature

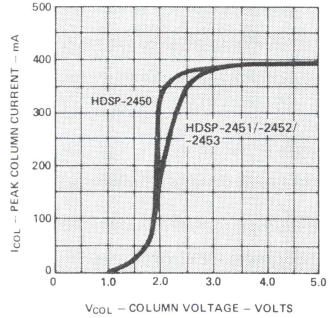


Figure 4. Peak Column Current vs. Column Voltage

Display Color	Ambient Lighting		
	Dim	Moderate	Bright
HDSP-2450 Standard Red	Panelgraphic Dark Red 63 Ruby Red 60 Chequers Red 118 Plexiglass 2423	Polaroid HNCP 37 3M Light Control Film Panelgraphic Gray 10 Chequers Grey 105	
HDSP-2451 Yellow	Panelgraphic Yellow 27 Chequers Amber 107		Polaroid Gray HNCP10 HOYA Yellowish-Orange HLF-608-3Y Marks Gray MCP-0301-8-10
HDSP-2452 HER	Panelgraphic Ruby Red 60 Chequers Red 112		Polaroid Gray HNCP10 HOYA Reddish-Orange HLF-608-5R Marks Gray MCP-0301-8-10 Marks Reddish-Orange MCP-0201-2-22
HDSP-2453 HP Green	Panelgraphic Green 48 Chequers Green 107		Polaroid Gray HNCP10 HOYA Yellow-Green HLF-608-1G Marks Yellow-Green MCP-0101-5-12

Figure 6. Contrast Enhancement Filters

100% Screening

Table I. Quality Level A of MIL-D-87157

Test Screen	MIL-STD-750 Method	Conditions
1. Precap Visual	2072	Interpreted by HP Procedure 5956-7512-52
2. High Temperature Storage	1032	T_A = 125° C, Time = 24 hours[3]
3. Temperature Cycling	1051	Condition B, 10 cycles, 15 min. dwell
4. Constant Acceleration	2006	10,000 G's at Y_1 orientation
5. Fine Leak	1071	Condition H
6. Gross Leak	1071	Condition C
7. Interim Electrical/Optical Tests[1]	—	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} and I_V Peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25° C
8. Burn-In[1]	1015	Condition B at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, T_A = +85° C, LED ON-Time Duty Factor = 5%, 35 Dots On; t = 160 hours
9. Final Electrical Test[2]	—	Same as Step 7
10. Delta Determinations	—	ΔI_{CC} = ±6 mA, ΔI_{IH} (clock) = ±8 μA, ΔI_{IH} (Data In) = ±5 μA ΔI_{OH} = ±50 μA, and ΔI_V = -20%, T_A = 25° C
11. External Visual[1]	2009	

Notes:
1. MIL-STD-883 Test Method applies.
2. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_O tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
3. T_A = 100° C for HDSP-2453.

Table II. Group A Electrical Tests — MIL-D-87157

Subgroup/Test	Parameters	LTPD
Subgroup 1 DC Electrical Tests at 25°C[1]	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test.	5
Subgroup 2 DC Electrical Tests at High Temperature[1]	Same as Subgroup 1, except delete I_V and visual function, T_A = +85°C	7
Subgroup 3 DC Electrical Tests at Low Temperature[1]	Same as Subgroup 1, except delete I_V and visual function, T_A = -55°C	7
Subgroup 4, 5, and 6 not applicable		
Subgroup 7 Optical and Functional Tests at 25°C	Satisfied by Subgroup 1	5
Subgroup 8 External Visual	MIL-STD-883 Method 2009	7

Note:
1. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.

Table IIIa. Group B, Class A and B of MIL-D-87157

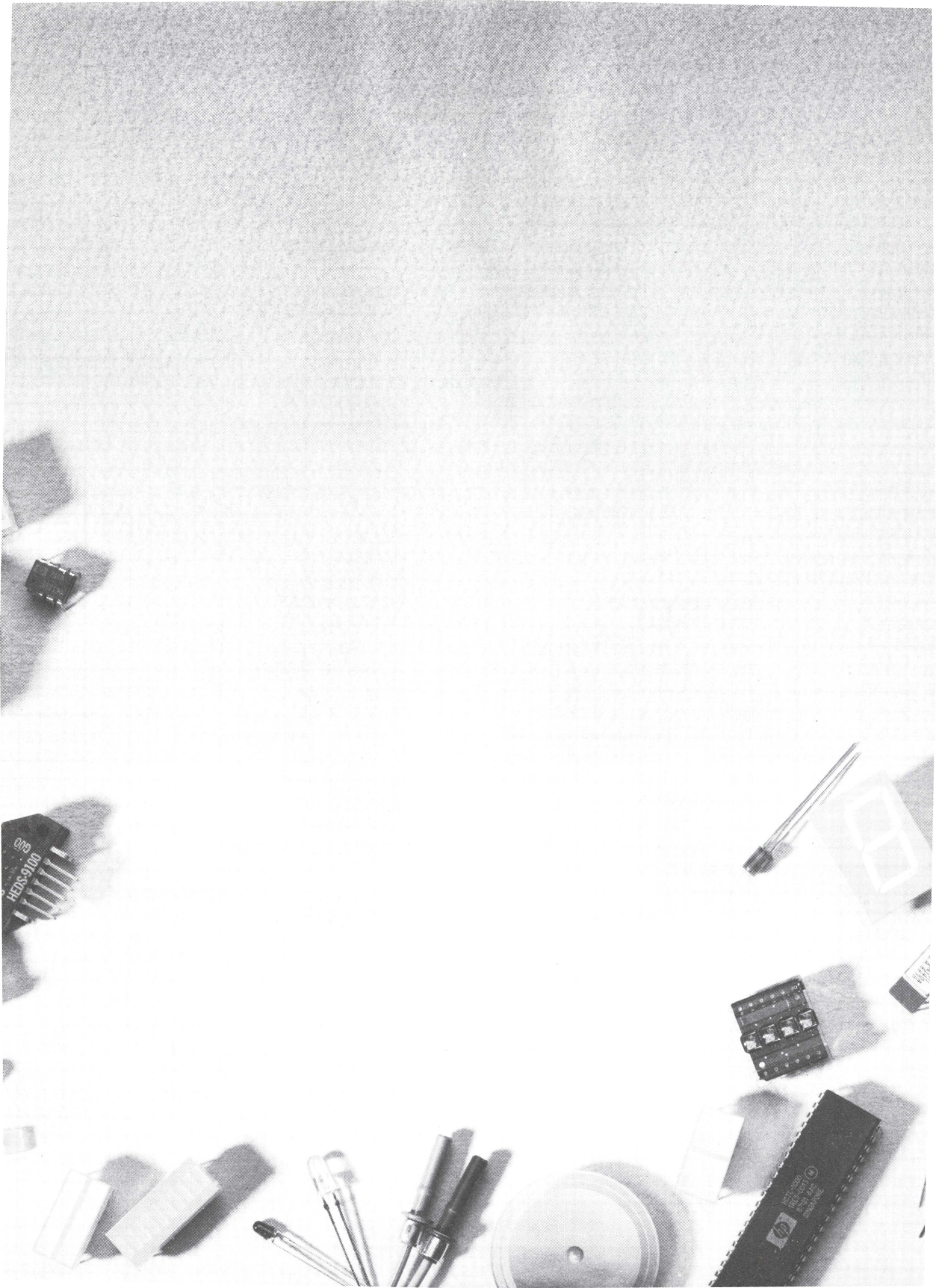
Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1 Resistance to Solvents	1022		4 Devices/ 0 Failures
Internal Visual and Design Verification[1]	2075[7]		1 Device/ 0 Failures
Subgroup 2[2,3] Solderability	2026	T_A = 245°C for 5 seconds	LTPD = 15
Subgroup 3 Thermal Shock (Temp. Cycle)	1051	Condition B1, 15 Min. Dwell	LTPD = 15
Moisture Resistance[4]	1021		
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Electrical/Optical Endpoints[5]	—	I_{CC} (at V_B = 0.4V and 2.4V), I_{COL} (at V_B = 0.4V and 2.4V), I_{IH} (V_B, Clock and Data In), I_{IL} (V_B, Clock and Data In), I_{OH}, I_{OL} Visual Function and I_V peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25°C	
Subgroup 4 Operating Life Test (340 hrs.)	1027	T_A = +85°C at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, LED ON-Time Duty Factor = 5%, 35 Dots On	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	
Subgroup 5 Non-operating (Storage) Life Test (340 hrs.)	1032	T_A = +125°C[6]	LTPD = 10
Electrical/Optical Endpoints[5]	—	Same as Subgroup 3	

Notes:
1. Visual inspection is performed through the display window.
2. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
3. The LTPD applies to the number of leads inspected except in no case shall less than 3 displays be used to provide the number of leads required.
4. Initial conditioning is a 15° inward bend for one cycle.
5. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
6. T_A = 100°C for HDSP-2453.
7. Equivalent to MIL-STD-883, Method 2014.

Table IVa. Group C, Class A and B of MIL-D-87157

Subgroup/Test	MIL-STD-750 Method	Conditions	Sample Size
Subgroup 1			
Physical Dimensions	2066		2 Devices/ 0 Failures
Subgroup 2[2]			
Lead Integrity[7, 9]	2004	Condition B2	LTPD = 15
Fine Leak	1071	Condition H	
Gross Leak	1071	Condition C	
Subgroup 3			
Shock	2016	1500G, Time = 0.5 ms, 5 blows in each orientation X_1, Y_1, Z_1	LTPD = 15
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	10,000G at Y_1 orientation	
External Visual[4]	1010 or 1011		
Electrical/Optical Endpoints[8]	—	I_{CC} (at V_B = 0.4V and 2.4V) I_{COL} (at V_B = 0.4V and 2.4V) I_{IH} (V_B, Clock and Data In) I_{IL} (V_B, Clock and Data In) I_{OH}, I_{OL}, Visual Function and Iv peak. V_{IH} and V_{IL} inputs are guaranteed by the electronic shift register test. T_A = 25°C.	
Subgroup 4[1,3]			
Salt Atmosphere	1041		LTPD = 15
External Visual[4]	1010 or 1011		
Subgroup 5			
Bond Strength[5]	2037	Condition A	LTPD = 20 (C = 0)
Subgroup 6			
Operating Life Test[6]	1026	T_A = +85°C at V_{CC} = V_B = 5.25V, V_{COL} = 3.5V, 35 Dots On	λ = 10
Electrical/Optical Endpoints[8]	—	Same as Subgroup 3	

Notes:
1. Whenever electrical/optical tests are not required as endpoints, electrical rejects may be used.
2. The LTPD applies to the number of leads inspected except in no case shall less than three displays be used to provide the number of leads required.
3. Solderability samples shall not be used.
4. Visual requirements shall be as specified in MIL-STD-883, Methods 1010 or 1011.
5. Displays may be selected prior to seal.
6. If a given inspection lot undergoing Group B inspection has been selected to satisfy Group C inspection requirements, the 340 hour life tests may be continued on test to 1000 hours in order to satisfy the Group C life test requirements. In such cases, either the 340 hour endpoint measurements shall be made a basis for Group B lot acceptance or the 1000 hour endpoint measurement shall be used as the basis for both Group B and Group C acceptance.
7. MIL-STD-883 test method applies.
8. Limits and conditions are per the electrical/optical characteristics. The I_{OH} and I_{OL} tests are the inverse of V_{OH} and V_{OL} specified in the electrical characteristics.
9. Initial conditioning is a 15 degree inward bend, 3 cycles.


HEDS-9100

Fiber Optics

- **Fiber Optic Transmitter/Receiver Components**
- **Evaluation Cables, Connectors, and Accessories**

Fiber Optics

HP's Commitment

Hewlett-Packard has been committed to Fiber Optics since the introduction of our first link in 1978. Years of technological experience with LED emitters, detectors, integrated circuits, precision optical packaging and optical fiber qualify HP to provide practical solutions for your application needs.

HP's unique combination of technologies and high volume manufacturing processes provide you with high quality transmitter and receiver components to meet a wide variety of computer, local area network, telecommunication and industrial communication needs.

Three major families of fiber optic components offer a wide range of application solutions. Each family is designed to match HP's technology to your application requirements resulting in minimum cost and maximum reliability. The design and specification of each of these families allow easy design-in and provide guaranteed performance.

Hewlett-Packard's method of specification assures guaranteed link performance and easy design-in. The transmitter optical power and receiver sensitivity are specified at the end of a length of test cable. These specifications take into account variations over temperature and connector tolerances. All families of components incorporate the fiber optic connector receptacle in the transmitter and receiver packages. Factory alignment of the emitter/detector inside the package minimizes the variation of coupled optical power, resulting in smaller dynamic range requirements for the receiver. The guaranteed distance and data rates for various transmitter/receiver pairs are shown in the following selection guide.

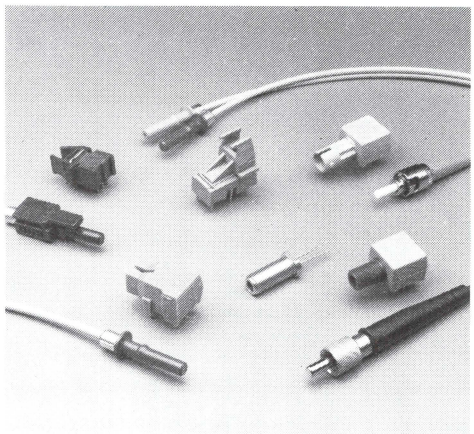
Hewlett-Packard offers a choice of fiber optic cable, either glass fiber or plastic, simplex or duplex, factory connectored or bulk. Connector attachment has been designed for your production line economy.

Versatile Link Components

Low cost and ease of use make this family of link components well suited for applications connecting computers to terminals, printers, plotters, test equipment, medical equipment and industrial control equipment. These links utilize 665 nm technology and 1 mm diameter plastic fiber cable. Assembling the plastic snap-in connectors onto the cable is extremely easy. The HFBR-0501 evaluation kit contains a complete working link including transmitter, receiver, 5 metres of connectored cable, extra connectors, polishing kit and technical literature.

Low Cost Miniature Link Components

This family offers a wide range of price/performance choice for computers, central office switch, PBX, local area network and industrial-control applications. These components utilize 820 nm technology and glass or plastic clad silica fiber cable. The unique design of the lensed optical coupling system makes this family of components extremely reliable. The Dual-In-Line Package requires no mounting hardware. The package is designed for auto insertion and wave soldering. These components are available for use with industry standard ST or SMA connectors. Specifications are provided for four fiber sizes: 62.5/125 μm, 50/125 μm, 100/140 μm and 200 μm Plastic Clad Silica (PCS) cable. Evaluation kits are available for both ST and SMA connectors. A transmitter, receiver, connectored cable and technical literature are contained in the evaluation kits.



HP Fiber Optic Performance Characteristics

The charts on this page illustrate the performance ranges of Hewlett-Packard's fiber optic components. Both charts are coded by family. To determine which family is appropriate for your deisgn, use the distance/data rate chart (Figure 1). The performance of each family incorporates the entire area below each boundary. Specific component choices and their associated optical-power budget are indicated in Figure 2.

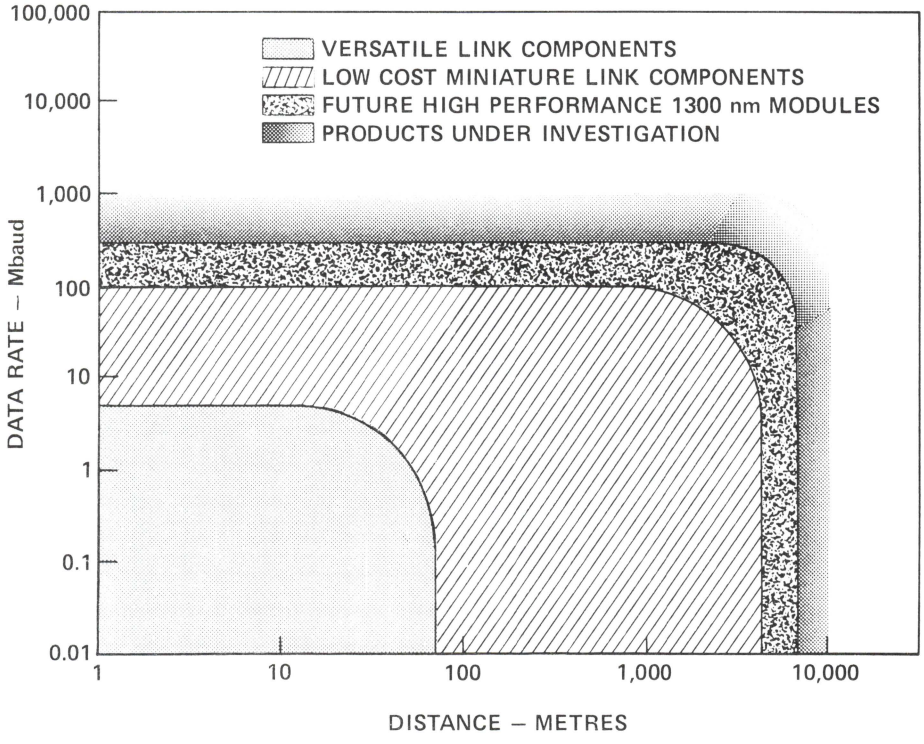


Figure 1

NOTES:

1. Optical power budget calculations are at 25°C.
2. For Link performance with other fiber sizes contact your local HP sales office.
3. All transmitters are LEDs except for 1300 nm modules which include a driver IC.

					VERSATILE LINK				LOW COST MINIATURE				FUTURE 1300 nm MODULES	
					TRANSMITTERS[3]									
					λ = 665 nm HFBR-1521/1531	λ = 665 nm HFBR-1522/1532	λ = 665 nm HFBR-1524/1534	λ = 665 nm HFBR-1523/1533	λ = 820 nm HFBR-1402/1412	λ = 820 nm HFBR-1402/1412	λ = 820 nm HFBR-1404/1414	λ = 820 nm HFBR-1404/1414	1300 nm Module	1300 nm Module
					COUPLED OPTICAL POWER (dBm)									
					-11.1 @ 60 mA	-8.2 @ 60 mA	-10.3 @ 60 mA	-8.2 @ 60 mA	-6.5 @ 60 mA	-12.0 @ 60 mA	-12.0 @ 60 mA	-16.5 @ 60 mA		
					FIBER SIZE (μm) (ATTENUATION)									
					1000 (0.25 dB/m)	1000 (0.25 dB/m)	1000 (0.25 dB/m)	1000 (0.25 dB/m)	200 PCS (5.3 dB/km)	100/140 (3.3 dB/km)	62.5/125 (2.8 dB/km)	50/125 (2.8 dB/km)	62.5/125 (2.8 dB/km)	62.5/125 (2.8 dB/km)
VERSATILE LINK	RECEIVERS	HFBR-2521/2531	FUNCTION	Logic IC	SENSITIVITY (dBm) -21.6	5 MBd 40 m								
		HFBR-2522/2532		Logic IC	-24		1 MBd 65 m							
		HFBR-2524/2534		Logic IC	-20			1 MBd 35 m						
		HFBR-2523/2533		Logic IC	-39				40 KBd 125 m					
LOW COST MINIATURE		HFBR-2402/2412		Logic IC	-25.4					5 MBd 3.5 Km	5 MBd 4.1 Km	5 MBd 4.7 Km	5 MBd 3.2 Km	
		HFBR-2404/2414		PIN/ Preamp	-36					5 MBd 5.6 Km	5 MBd 7.3 Km	5 MBd 8.6 Km	5 MBd 7.0 Km	
		HFBR-2404/2414		PIN/ Preamp	-33					30 MBd 600 m*	30 MBd 3.0 Km*	30 MBd 4.0 Km*	30 MBd 4.0 Km*	
		HFBR-2406/2416		PIN/ Preamp	-35.6					30 MBd 650 m*	30 MBd 3.3 Km*	30 MBd 4.5 Km*	30 MBd 4.5 Km*	
		HFBR-2406/2416		PIN/ Preamp	-32					100 MBd 130 m*	100 MBd 750 m*	100 MBd 1.0 Km*	100 MBd 1.0 Km*	
FUTURE 1300 nm MODULES		1300 nm Module		Logic IC									125 MBd 2.0 Km	
		1300 nm Module		Logic IC										200 MBd 2.0 Km

Future 1300 nm modules are discussed on page 8-3.

*Distance is limited by a combination of fiber bandwidth and transmitter optical rise/fall time and LED spectral width.

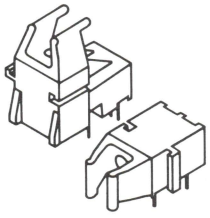
Figure 2

Fiber Optic Selection Guide

The newer transmitter/receiver product families located at the front of the selection guide provide the designer with significantly improved price/performance benefits over older products. These newer product families have been specifically designed for easy use in high volume manufacturing operations. Each can be auto-inserted and wave soldered. No mounting hardware is required.

The optical-power budget is determined by subtracting the receiver sensitivity (dBm) from the transmitter optical output power (dBm). The distance specification can be calculated simply by dividing the optical-power budget (dBm) by the cable attenuation (dB/km).

Versatile Link Family

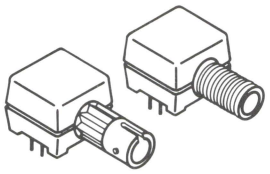


Features: Dual-in-line package, horizontal and vertical PCB mounting, plastic snap-in connectors, specified for 1 mm dia. plastic fiber, TTL/CMOS compatible output, auto insertable, wave solderable.

Products/Part Numbers			Description		Page No.
Evaluation Kit HFBR-0501			HFBR-1524 Transmitter, HFBR-2524 Receiver, 5 metre connectored cable, connectors, bulkhead feedthrough adapter, polishing kit, literature.		8-13
Transmitter/Receiver Pairs	Horizontal	Vertical	Distance*	Data Rate	
5 MBd High Performance Link	HFBR-1521/2521	HFBR-1531/2531	40 m	5 MBd	
1 MBd High Performance Link	HFBR-1522/2522	HFBR-1532/2532	65 m	1 MBd	
1 MBd Standard Performance Link	HFBR-1524/2524	HFBR-1534/2534	35 m	1 MBd	
40 KBd Extended Distance Link	HFBR-1523/2523	HFBR-1533/2533	125 m	40 KBd	
Low Current Link	HFBR-1523/1523	HFBR-1533/2523	40 m	40 KBd	
Photo Interrupter Link	HFBR-1523/1523	HFBR-1533/1523	N.A.	20 KHz	
	HFBR-1522/2522	HFBR-1532/2532	N.A.	500 KHz	
Plastic Fiber Cable	Simplex	Duplex			
Standard Attenuation	Various P/N	Various P/N	Connectored cable available in standard lengths.		
Improved Attenuation	Various P/N	N.A.	Unconnectored cable available in 500 m reels.		
Connectors					
Simplex Standard		HFBR-4501	Gray connector/crimp ring		
		HFBR-4511	Blue connector/crimp ring		
Simplex Latching		HFBR-4503	Gray connector/crimp ring		
		HFBR-4513	Blue connector/crimp ring		
Duplex		HFBR-4506	Parchment connector/crimp ring		
Polishing Kit					
	HFBR-4593		Plastic polishing fixture (used for all connectors), abrasive paper, lapping film		
Bulkhead Feedthrough/in-line splice					
	HFBR-4505		Gray bulkhead feedthrough adapter		
	HFBR-4515		Blue bulkhead feedthrough adapter		

*Link performance at 25°C, improved attenuation cable.

Low Cost Miniature Link Family

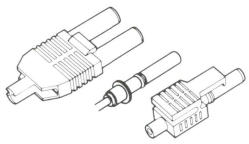


Features: Dual-in-line package, interfaces directly with ST or SMA connectors, specified for use with 50/125 μm, 62.5/125 μm, 100/140 μm and 200 μm Plastic Coated Silica (PCS) fiber. Auto insertable, wave solderable, no mounting hardware required.

Products/Part Numbers		Description		Page No.
Evaluation Kits				8-37
HFBR-0410 (ST)		HFBR-1412 transmitter, HFBR-2412 receiver, 3 metre connectored cable, literature		
HFBR-0400 (SMA)		HFBR-1402 transmitter, HFBR-2402 receiver, 2 metre connectored cable, literature		
Transmitter/Receiver Pairs				
ST Series	SMA Series	Optical Power Budget*	Data Rate	
HFBR-1412/2412	HFBR-1402/2402	20.5 dB (200 μm fiber) 15 dB (100/140 μm fiber)	5 MBd 5 MBd	
HFBR-1414/2412	HFBR-1404/2402	15 dB (62.5/125 μm fiber) 10.5 dB (50/125 μm fiber)	5 MBd 5 MBd	
HFBR-1412/2414	HFBR-1402/2404	18 dB (100/140 μm fiber) 13.5 dB (100/140 μm fiber)	5 MBd 30 MBd	
HFBR-1414/2414	HFBR-1404/2404	18 dB (62.5/125 μm fiber) 13.5 dB (62.5/125 μm fiber)	5 MBd 30 MBd	
HFBR-1412/2416	HFBR-1402/2406	21 dB (100/140 μm fiber) 19 dB (100/140 μm fiber)	30 MBd 150 MBd	
HFBR-1414/2416	HFBR-1404/2406	21 dB (62.5/125 μm fiber) 19 dB (62.5/125 μm fiber)	30 MBd 100 MBd	
HFBR-1412 Standard transmitter — ST HFBR-1402 Standard Transmitter — SMA		Optimized for large size fiber such as 100/140 μm and 200 μm PCS		
HFBR-1414 High Power Transmitter — ST HFBR-1404 High Power Transmitter — SMA		Optimized for small size fibers such as 50/125 μm or 62.5/125 μm		
HFBR-2412 5 MBd Receiver — ST HFBR-2402 5 MBd Receiver — SMA		TTL/CMOS compatible receiver with -25.4 dBm sensitivity		
HFBR-2414 25 MHz Receiver — ST HFBR-2404 25 MHz Receiver — SMA		PIN - preamp receiver for data rates up to 35 MBd		
HFBR-2416 125 MHz Receiver — ST HFBR-2406 125 MHz Receiver — SMA		PIN - preamp receiver for data rates up to 150 MBd		

* Link performance at 25°C.

Connectored Cable for Versatile Link

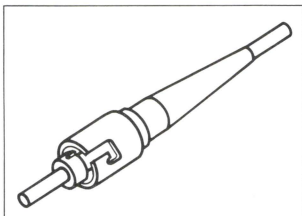


Features: Fully specified fiber cable, simplex or duplex (zip cord style), factory installed connectors or unconnectored, standard or improved attenuation cable, standard simplex, simplex latching or duplex connectors.

Product/ Part Number		Description																		
		Fiber Type		Connector Style				Cable Type		Cable Length										
		Standard Plastic	Improved Plastic	Latching Simplex	Standard Simplex	Duplex	Uncon-nectored	Single Channel	Dual Channel	0.1 M	0.5 M	1 M	5 M	10 M	20 M	30 M	45 M	60 M	500 M	Page No.
New P/N	Old HP P/N	P	Q	L	N	M	U	S	D	1 DM	5 DM	001	005	010	020	030	045	060	500	
HFBR-PNS1DM	-3511	X			X			X		X										8-13
-PNS5DM	-3512	X			X			X			X									
-PNS001	-3513	X			X			X				X								
-PNS005	-3514	X			X			X					X							
-PNS010	-3515	X			X			X						X						
-PNS020	-3516	X			X			X							X					
-PNS030	-3517	X			X			X								X				
-PNS045	-3518	X			X			X									X			
-PNS060	-3519	X			X			X										X		
HFBR-QNS001	-3530		X		X			X				X								
-QNS005	-3530		X		X			X					X							
-QNS010	-3530		X		X			X						X						
-QNS020	-3530		X		X			X							X					
-QNS030	-3530		X		X			X								X				
-QNS045	-3530		X		X			X									X			
-QNS060	-3530		X		X			X										X		
HFBR-PLS1DM	-3521	X		X				X		X										
-PLS5DM	-3522	X		X				X			X									
-PLS001	-3523	X		X				X				X								
-PLS005	-3524	X		X				X					X							
-PLS010	-3525	X		X				X						X						
-PLS020	-3526	X		X				X							X					
-PLS030	-3527	X		X				X								X				
-PLS045	-3528	X		X				X									X			
-PLS060	-3529	X		X				X										X		
HFBR-QLS001	-3540		X	X				X				X								
-QLS005	-3540		X	X				X					X							
-QLS010	-3540		X	X				X						X						
-QLS020	-3540		X	X				X							X					
-QLS030	-3540		X	X				X								X				
-QLS045	-3540		X	X				X									X			
-QLS060	-3540		X	X				X										X		
HFBR-PMD5DM	-3632	X				X			X		X									
-PMD001	-3633	X				X			X			X								
-PMD005	-3634	X				X			X				X							
-PMD010	-3635	X				X			X					X						
-PMD020	-3636	X				X			X						X					
-PMD030	-3637	X				X			X							X				
-PMD045	-3638	X				X			X								X			
-PMD060	-3639	X				X			X									X		
HFBR-PND5DM	-3612	X			X				X		X									
-PND001	-3613	X			X				X			X								
-PND005	-3614	X			X				X				X							
-PND010	-3615	X			X				X					X						
-PND020	-3616	X			X				X						X					
-PND030	-3617	X			X				X							X				
-PND045	-3618	X			X				X								X			
-PND060	-3619	X			X				X									X		
HFBR-PUS500	-3581	X					X	X											X	
-QUS500	-3582		X				X	X											X	
-PUD500	-3681	X					X		X										X	

FIBER OPTICS

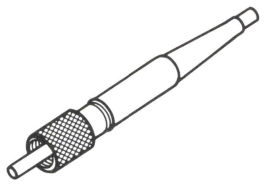
ST Connectored Evaluation Cables



Features: Evaluation cables for link testing, factory installed ST connectors, simplex cables only.

	Description							
	Fiber Size (μm)			Connector	Cable	Length		Page
Part Number	100/140	62.5/125	50/125	ST-Ceramic	Simplex	1 metre	10 metres	No.
HFBR-AXS001	X			X	X	X		8-37
HFBR-AXS010	X			X	X		X	
HFBR-BXS001		X		X	X	X		
HFBR-BXS010		X		X	X		X	
HFBR-CXS001			X	X	X	X		
HFBR-CXS010			X	X	X		X	

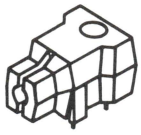
SMA Connectored Cable



Features: Fully specified fiber cable, simplex or duplex (zip cord style), factory installed SMA connectors or unconnectored.

		Description												
		Fiber Size	Connector Style		Cable Type		Cable Length							
Product/ Part Number	Old HP P/N	100/140	SMA	Uncon-nectored	Single Channel	Dual Channel	1 M	5 M	10 M	25 M	50 M	100 M	1000 M	Page No.
		A	W	U	S	D	001	005	010	025	050	100	1 KM	
HFBR-AWS001	-3000	X	X		X		X							8-57
-AWS005	-3000	X	X		X			X						
-AWS010	-3021	X	X		X				X					
-AWS025	-3000	X	X		X					X				
-AWS050	-3000	X	X		X						X			
-AWS100	-3000	X	X		X							X		
HFBR-AWD005	-3100	X	X			X		X						
-AWD010	-3100	X	X			X			X					
-AWD025	-3100	X	X			X				X				
-AWD050	-3100	X	X			X					X			
-AWD100	-3100	X	X			X						X		
HFBR-AUS100	-3200	X		X	X							X		
-AUS1KM	-3200	X		X	X								X	
HFBR-AUD100	-3300	X		X		X						X		
-AUD1KM	-3300	X		X		X							X	

Snap-In Link Family



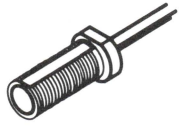
Features: Operate with 1 mm dia. plastic fiber, plastic snap-in connector compatible (standard simplex only), TTL compatible output.

FOR NEW DESIGNS: Refer to the Versatile Link Family on page 8-13 to achieve the best price/performance value.

Products/Part Numbers		Description		Page No.
Transmitter/Receiver Pairs		Distance*	Data Rate*	8-60
5 MBd Link	HFBR-1510/-2501	40 metre	5 MBd	
1 MBd Link	HFBR-1502/-2502	65 metre	1 MBd	
Extended Distance Link	HFBR-1512/-2503	125 metre	40 kBd	
Low Current Link	HFBR-1512/-2503	40 metre	40 kBd	
Photo Interrupter Link	HFBR-1512/-2503	N/A	20 kHz	
	HFBR-1502/-2502	N/A	500 kHz	

*Link performance at 25°C, improved attenuation cable.

Miniature Link Family



Features: Interfaces directly with SMA style connectors, specified for use with 100/140 μm fiber. Precision metal connector interface.

FOR NEW DESIGNS: Refer to the Low Cost Miniature Link Family on page 8-37 to achieve the best price/performance value.

Products/Part Numbers	Description		Page No.
Transmitter/Receiver Pairs	Distance*	Data Rate*	8-78
HFBR-1202/-2202	800 metre	5 MBd	
HFBR-1202/-2204	1200 metre	40 MBd	
HFBR-1204/-2202	1800 metre	5 MBd	
HFBR-1204/-2204	2100 metre	40 MBd	
HFBR-1204/-2208	500 metre (typical)	125 MBd (typical)	
Mounting Hardware HFBR-4202	PCB mounting bracket, EMI shield, misc, hardware for HFBR-1202/-1204/-2202/-2204/2208.		

*Link performance at 25°C.

The following products are available but not recommended for new designs.
For literature on these products please contact your local HP sales office.

Products/Part Nos.	Description/Features
Transmitter/Receiver Pairs	Specified for 100/140 μm fiber, HP style connector, TTL compatible, Link monitor.
	Distance* / Data Rate* / Connector Style
HFBR-1001/-2001	180 metre / 10 MBd / HFBR-4000
HFBR-1002/-2001	1500 metre / 10 MBd / HFBR-4000
RS-232-C/V.24 to Fiber Optic Multiplexer	
39301A Multiplexer	1250 metres length, 19.2 kbps/channel data rate, 16 channels RS-232-C Input/Output
PIN Photodiodes	
5082-4200 Series	High Speed PIN Photodiodes for use in Fiber Optic Applications Variety of packages, high speed, low capacitance, low noise.
HP Style Connectors	
HFBR-4000	Metal body, metal ferrule
HFBR-3099	Connector-connector junction, bulkhead feedthrough for HFBR-4000 connector.
HP Style Connector Assembly Tools	
HFBR-0100	Field installation kit for HFBR-4000 connectors (includes case, tools, consumables)
HFBR-0101	Replacement consumables for HFBR-0100 Kit
HFBR-0102	Custom tool set only

HP Style Connectored Cable		Fully specified 100/140 μm fiber cable, simplex or duplex (zip cord style), factory installed HP style connectors										
		Description										
		Fiber Size	Connector Style		Cable Type		Cable Length					
Product/ Part Number	Old HP P/N	100/140	HFBR-4000	Unconnectored	Single Channel	Dual Channel	1 M	5 M	10 M	25 M	50 M	100 M
		A	H	U	S	D	001	005	010	025	050	100
HFBR-AHS001	-3000	X	X		X		X					
-AHS005	-3000	X	X		X			X				
-AHS010	-3001	X	X		X				X			
-AHS025	-3000	X	X		X					X		
-AHS050	-3000	X	X		X						X	
-AHS100	-3000	X	X		X							X
HFBR-AHD005	-3100	X	X			X		X				
-AHD010	-3100	X	X			X			X			
-AHD025	-3100	X	X			X				X		
-AHD050	-3100	X	X			X					X	
-AHD100	-3100	X	X			X						X

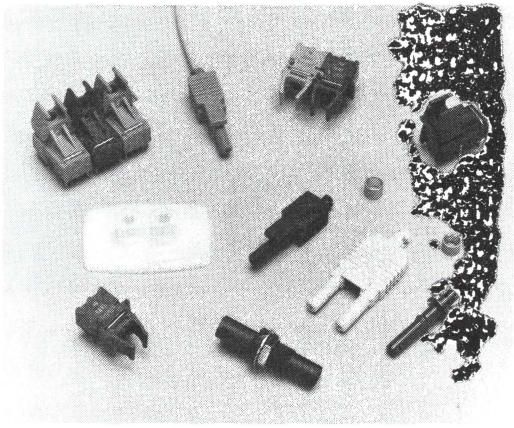
HEWLETT PACKARD

VERSATILE LINK
The Versatile Fiber Optic Connection

HFBR-0501* SERIES

Features

- LOW COST FIBER OPTIC COMPONENTS
- GUARANTEED LINK PERFORMANCE OVER TEMPERATURE
  High Speed Links: dc to 5 MBd
  Extended Distance Links: up to 82 m
  Low Current Link: 6 mA Peak Supply Current
  Low Cost Standard Link: dc to 1 MBd
  Photo Interrupter Link
- COMPACT, LOW PROFILE PACKAGES
  Horizontal and Vertical Mounting
  "N-plex" Stackable
  Flame Retardant
- EASY TO USE RECEIVERS
  TTL, CMOS Compatible Output Level
  High Noise Immunity
- EASY CONNECTORING
  Simplex, Duplex and Latching Connectors
  Flame Retardant Material
- LOW LOSS PLASTIC CABLE
  Selected Super Low Loss Simplex
  Simplex and Zip Cord Style Duplex
  Flame Retardant
- NO OPTICAL DESIGN REQUIRED
- AUTO-INSERTABLE AND WAVE SOLDERABLE
- DEMONSTRATED RELIABILITY @ 40° C EXCEEDS 3 MILLION HOURS MTBF



Description

The Versatile Link series is a complete family of fiber optic link components for applications requiring a low cost solution. The HFBR-0501 series includes transmitters, receivers, connectors and cable specified for easy design. This series of components is ideal for solving problems with voltage isolation/insulation, EMI/RFI immunity or data security. The Link design is simplified by the logic compatible receivers and complete specifications for each component. No optical design is necessary. The key optical and electrical parameters of links configured with the HFBR-0501 family are fully guaranteed from 0° to 70° C. A wide variety of package configurations and connectors provide the designer with numerous mechanical solutions to meet application requirements. The transmitter and receiver components have been designed for use in high volume/low cost assembly processes such as auto-insertion and wave soldering.

Versatile Link Applications

- Reduction of lightning/voltage transient susceptability
- Motor controller triggering
- Data communications and Local Area Networks
- Electromagnetic Compatibility (EMC) for regulated systems: FCC, VDE, CSA, etc.
- Tempest—secure data processing equipment
- Isolation in test and measurement instruments
- Error free signalling for industrial and manufacturing equipment
- Automotive communications and control networks
- Power supply control
- Communication and isolation in medical instruments
- Noise immune communication in audio and video equipment
- Remote photo interrupter for office and industrial equipment
- Robotics communication

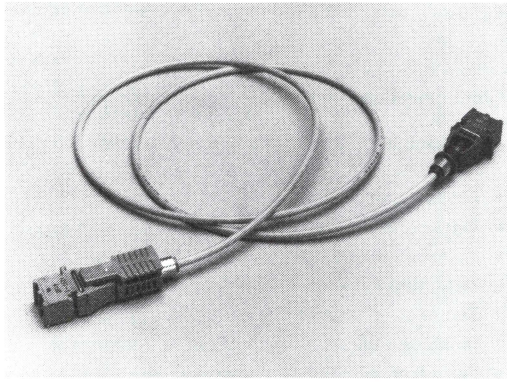
Link Selection Guide

Specific Product Numbers and Component Selection Guide on page 23.

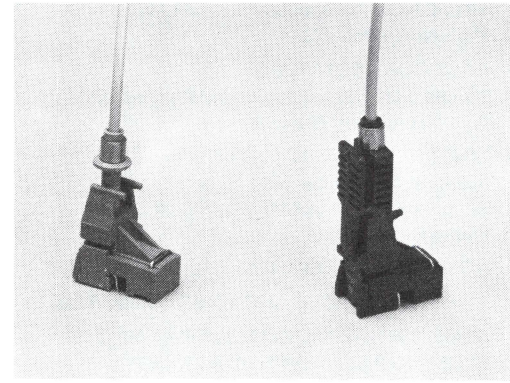
Versatile Link		Guaranteed Minimum Link Length Metres				Typical Link Length Metres		Page
		0°C - 70°C		25°C		25°C		
		Standard Cable	Improved Cable	Standard Cable	Improved Cable	Standard Cable	Improved Cable	
High Performance	5 MBd	12	17	17	24	35	40	8-16
High Performance	1 MBd	24	34	30	41	50	65	8-16
Low Current Link	40 kBd	8	11	—	—	30	35	8-16
Extended Distance Link	40 kBd	60	82	65	90	100	125	8-16
Standard	1 MBd	5	7	11	15	30	40	8-16
Photo Interrupter	500 kHz	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	8-22
Evaluation Kit	1 MBd (Standard)	Contents: Horizontal transmitter, horizontal receiver packages; 5 metres of simplex cable with simplex and simplex latching connectors installed; individual connectors: simplex, duplex, simplex latching, bulkhead adapter; polishing tool, abrasive paper, literature.						8-35

Versatile Link Product Family

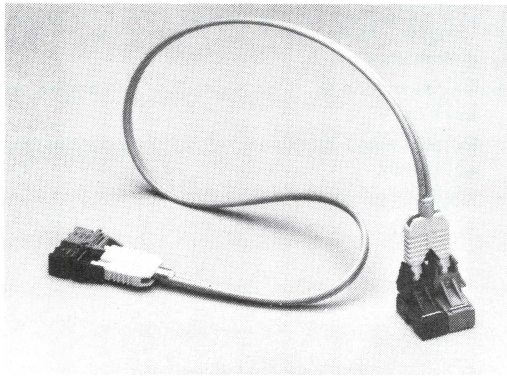
5 MBd, 1 MBd and 40 kBd FIBER OPTIC LINKS



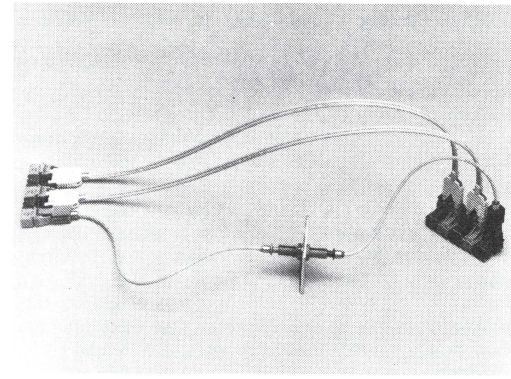
Simplex Link — Horizontal Packages



Simplex Link — Vertical Packages



Duplex Link — Combination of Horizontal & Vertical Packages



N-Plex Link — Combinations

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Versatile Link Configurations 2
Versatile Link Product Description 3
Designing with Versatile Link 3
Manufacturing with Versatile Link 4
Versatile Link Performance
- High Performance 5 MBd Link 4
- High Performance 1 MBd Link 4
- Low Current Extended Distance 40 kBd Link 4
- Standard 1 MBd Link 4

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Receiver Specifications 13
Cable Specifications 15
Connector Descriptions 16
Connector Specifications 18
Connectoring 18
Versatile Link Mechanical Dimensions 20
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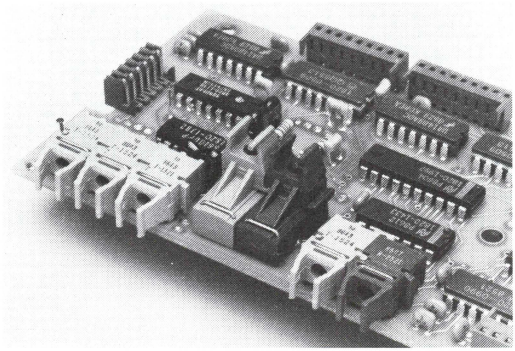
Versatile Link Product Description

Mechanical: The compact Versatile Link package is made of a flame retardant material (UL V-0) in a standard, eight pin dual-in-line package (DIP) with 7.6 millimetre (0.3 inch) pin spacing. Vertical and horizontal mountable parts are available. These low profile Versatile Link packages are stackable and are enclosed to provide a dust resistant seal. Snap action simplex, simplex latching, and duplex connectors are offered with simplex or duplex cables.

Electrical: Transmitters incorporate a 660 nanometre light emitting diode (LED). Receivers include a monolithic DC coupled, digital IC receiver with open collector Schottky output transistor. An internal pullup resistor is available for use in the HFBR-25X1/2/4 receivers. Transmitter and receiver are compatible with standard TTL circuitry. A shield has been integrated into the receiver IC to provide additional, localized noise immunity.

Optical: Internal optics have been optimized for use with 1 mm diameter plastic optical fiber. Versatile Link specifications incorporate all component interface losses. Therefore, the need of optical calculations for common link applications is eliminated.

Optical power budget is graphically displayed to facilitate electrical design for customized links.



Designing with Versatile Link

When designing with Versatile Link, the following topics should be considered:

Distance and Data Rate

Distances and data rates guaranteed with Versatile Link depend upon the Versatile Link transmitter/receiver pair chosen. See the Versatile Link guide (Page 4).

Typically, a data rate requirement is first specified. This determines the choice of the 5 MBd, 1 MBd or 40 kBd Versatile Link components. Distances guaranteed with Versatile Link then depend upon choice of cable, specific drive condition and circuit configuration. Extended distance operation is possible with pulsed operation of the LED (see Figure 2a, 2b, 2c, 2d, 2e and 2f dotted lines.)

Drive circuits are described on page 7. Cable is discussed on page 15. Pulsed operation of the LED at larger current will result in increased pulse width distortion of the receiver output signal.

Versatile Link can also be used as a photo interrupter at frequencies up to 500 KHz. This is described on page 10.

Package Orientation

As shown in the photograph, Versatile Link is available in vertical and horizontal packages. Performance and pinouts for the two packages are identical. To provide additional attachment support for the Vertical Versatile Link housing, the designer has the option of using a self-tapping screw (2-56) through a printed circuit board into a mounting hole at the bottom of the package. For most applications this is not necessary.

Connector Style

As shown, Versatile Link can be used with three snap-in connectors: simplex, simplex latching, and duplex.

The simplex connector is intended for applications requiring simple, stable connection capability with a moderate retention force. The simplex latching connector provides similar convenience with a larger retention force. Connector/cable retention force can be improved by using a RTV adhesive within the connector. A suggested adhesive is 3M Company product: RTV-739.

Versatile Link components and simplex connectors are color coded to eliminate confusion when making connections. Versatile Link transmitters are gray and Versatile Link receivers are blue.

The duplex connector connects a cable containing two fibers to two similar Versatile Link components. A lockout feature ensures the connection can be made in only one orientation. The duplex connector is intended for Versatile Link components "n-plexed" together, as discussed in the next section.

N-plexing

Versatile Link components can be stacked or interlocked (n-plexed) together to minimize use of printed circuit board space and to provide efficient, dual connections via the duplex connector. Up to eight identical package styles can be n-plexed and inserted by hand into a printed circuit board without difficulty. However, auto-insertability of stacked units becomes limited when more than two packages are n-plexed together.

Cable

Two cable versions are available: Simplex (single channel) and color coded duplex (dual channel). Each version of the cable is flame retardant (UL VW-1) and of low optical loss.

Two grades of the simplex cable are available: standard cable and improved cable. Improved cable is recommended for applications requiring longer distance needs, as reflected in the Link Selection Guide on page 2. Flexible cable construction allows simple cable installation techniques. Cables are discussed in detail on page 15.

Accessories

A variety of accessories are available. The bulkhead feedthrough adapter discussed on page 16 can be used to mate two simplex snap-in connectors. It can be used either as a splice or a panel feedthrough for a panel thickness < 4.1 mm (0.16 inch).

Several accessories are offered to help with proper fiber/connector polishing. These are shown on page 16.

Manufacturing with Versatile Link

Non-stacked Versatile Link parts require no special handling during assembly of units onto printed circuit boards. Versatile Link components are auto-insertable. When wave soldering is performed with Versatile Link components, an optical port plug is recommended to be used to prevent contamination of the port. Commercially available port plugs are obtainable from companies such as Sinclair & Rush Co., Saint Louis, MO. Water soluable fluxes, not rosin based fluxes, are recommended for use with Versatile Link components. Proper cleaners are Freon TMS (DuPont) and halide-free solvents.

Refer to the Connectoring Section on page 18 for details of connectors and cable connectoring.

Versatile Link Performance

5 MEGABITS PER SECOND (NRZ)
1 MEGABIT PER SECOND (NRZ)
40 KILOBITS PER SECOND (NRZ)

The 5 Megabaud (MBd) Versatile Link is guaranteed to perform from DC to 5 Mb/s (megabits per second, NRZ). Distances up to 17 metres are guaranteed when the transmitter is driven with a current of 60 milliamperes. This represents worst case performance throughout the temperature range of 0 to 70 degrees centigrade. With the required drive circuit of Figure 1b and at 60 milliamp drive current, the 1 Megabaud Versatile Link has guaranteed performance over 0 to 70 degrees centigrade from DC to 1 Mb/s (NRZ) up to 34 metres.

The low current link requires only 6 mA peak supply current for the transmitter and receiver combined to achieve an 11 metre link. Extended distances up to 82 metres can be achieved at a maximum transmitter drive current of 60 mA peak. The 40 kBd Versatile Link is guaranteed to perform from DC to 40 kb/s (NRZ) over 0° to 70° C up to the distances just described.

Receivers are compatible with LSTTL, TTL, CMOS logic levels and offer a choice of an internal pull-up resistor or an open collector output. Horizontal or vertical packages provide identical performance and are compatible with simplex, simplex latching, and duplex connectors. Refer to the connector section (page 16) and the cable section (page 15) for further information about these products. A list of specific part numbers is found below and in the Selection Guide on page 23.

VERSATILE LINK GUIDE

Versatile Link		Unit	Horizontal Package	Vertical Package	Cable Link Length	
					Standard Cable	Improved Cable
High Performance	5 MBd	T_X	HFBR-1521	HFBR-1531	12 metres	17 metres
		R_X	HFBR-2521	HFBR-2531		
High Performance	1 MBd	T_X	HFBR-1522	HFBR-1532	24 metres	34 metres
		R_X	HFBR-2522	HFBR-2532		
Low Current/ Extended Distance	40 kBd	T_X R_X	HFBR-1523 HFBR-2523	HFBR-1533 HFBR-2533	8 metres/ 60 metres	11 metres/ 82 metres
Standard	1 MBd	T_X	HFBR-1524	HFBR-1534	5 metres	7 metres
		R_X	HFBR-2524	HFBR-2534		

RECOMMENDED OPERATING CONDITIONS

Parameter		Symbol	Min.	Max.	Units	Ref.
Ambient Temperature		T_A	0	70	°C	
Transmitter Peak Forward Current		$I_{F\,PK}$	10	750	mA	Note 1,8
Avg. Forward Current		$I_{F\,AV}$		60	mA	
Receiver Supply Voltage	HFBR-25X3	V_{CC}	4.50	5.50	V	Note 2
	HFBR-25X1/25X2/25X4		4.75	5.25		
Output Voltage	HFBR-25X3	V_O		V_{CC}	V	
	HFBR-25X1/25X2/25X4			18		
Fanout (TTL)	HFBR-25X3	N		1		
	HFBR-25X1/25X2/25X4			5		

SYSTEM PERFORMANCE Under recommended operating conditions unless otherwise specified.

	Parameter	Symbol	Min.	Typ.[5]	Max.	Units	Conditions		Ref.
High Performance 5 MBd	Data Rate		dc		5	MBd	BER ≤ 10^{-9}, PRBS: 2^7-1		
	Link Distance with Standard Cable	ℓ	12			m	I_{FPK} = 60mA		Fig. 2a Note 7
			17	35		m	I_{FPK} = 60 mA, 25°C		
	Link Distance with Improved Cable	ℓ	17			m	I_{FPK} = 60mA		Fig. 2b Note 7
			24	40		m	I_{FPK} = 60 mA, 25°C		
	Propagation Delay	t_{PLH}		80	140	ns	R_L = 560 Ω, C_L = 30 pF ℓ = 0.5 metre -21.6 ≤ P_R ≤ -9.5 dBm		Fig. 3, 5 Notes 3, 6
		t_{PHL}		50	140	ns			
	Pulse Width Distortion	t_D		30		ns	P_R = -15 dBm R_L = 560 Ω, C_L = 30 pF		Fig. 3, 4 Note 4
High Performance 1 MBd	Data Rate		dc		1	MBd	BER ≤ 10^{-9}, PRBS: 2^7-1		
	Link Distance with Standard Cable	ℓ	24			m	I_{FPK} = 60 mA		Fig. 2a Notes 1, 7, 8
			30	50		m	I_{FPK} = 60 mA, 25°C		
			30			m	I_{FPK} = 120 mA	50% Duty Factor	
			36	60		m	I_{FPK} = 120 mA, 25°C	50% Duty Factor	
	Link Distance with Improved Cable	ℓ	34			m	I_{FPK} = 60 mA		Fig. 2b Notes 1, 7, 8
			41	65		m	I_{FPK} = 60 mA, 25°C		
			44			m	I_{FPK} = 120 mA	50% Duty Factor	
			51	75		m	I_{FPK} = 120 mA, 25°C	50% Duty Factor	
	Propagation Delay	t_{PLH}		180	250	ns	R_L = 560 Ω, C_L = 30 pF ℓ = 0.5 metre P_R = -24 dBm		Fig. 3, 5 Notes 3, 8
		t_{PHL}		100	140	ns			
	Pulse Width Distortion	t_D		80		ns	P_R = -24 dBm R_L = 560 Ω, C_L = 30 pF		Fig. 3, 4 Notes 4, 8

SYSTEM PERFORMANCE Under recommended operating conditions unless otherwise specified.

Link	Parameter	Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Low Current/ Extended Distance 40 kBd	Data Rate		dc		40	kBd	BER ≤ 10^{-9}, PRBS: 2^7-1	
	Link Distance with Standard Cable	ℓ	8	30		m	I_{FPK} = 2 mA	Fig. 2c Note 7
			60	100		m	I_{FPK} = 60 mA	
	Link Distance with Improved Cable	ℓ	11	35		m	I_{FPK} = 2 mA	Fig. 2d Note 7
			82	125		m	I_{FPK} = 60 mA	
	Propagation Delay	t_{PLH}		4		μs	R_L = 3.3 kΩ, C_L = 30 pF = 1 metre P_R = -25 dBm	Fig. 3, 7 Note 3
		t_{PHL}		2.5		μs		
	Pulse Width Distortion	t_D			7.0	μs	-39 ≤ P_R ≤ -14 dBm R_L = 3.3 kΩ, C_L = 30 pF	Fig. 3, 6 Note 4
Standard 1 MBd	Data Rate		dc		1	MBd	BER ≤ 10^{-9}, PRBS: 2^7-1	
	Link Distance with Standard Cable	ℓ	5			m	I_{FPK} = 60 mA	Fig. 2e Notes 1, 7, 8
			11	30		m	I_{FPK} = 60 mA, 25°C	
			12			m	I_{FPK} = 120 mA, 50% Duty Factor	
			18	40		m	I_{FPK} = 120 mA, 25°C, 50% Duty Factor	
	Link Distance with Improved Cable	ℓ	7			m	I_{FPK} = 60 mA	Fig. 2f Notes 1, 7, 8
			15	40		m	I_{FPK} = 60 mA, 25°C	
			17			m	I_{FPK} = 120 mA, 50% Duty Factor	
			25	50		m	I_{FPK} = 120 mA, 25°C, 50% Duty Factor	
	Propagation Delay	t_{PLH}		180	250	ns	R_L = 560 Ω, C_L = 30 pF ℓ = 0.5 metre P_R = -20 dBm	Fig. 3, 5 Notes 3, 8
		t_{PHL}		100	140	ns		
	Pulse Width Distortion	t_D		80		ns	P_R = -20 dBm R_L = 560 Ω, C_L = 30 pF	Fig. 3, 4 Notes 4, 8

Notes:

1. For I_{FPK} > 80 mA, the duty factor must be such as to keep I_{FDC} ≤ 80 mA. In addition, for I_{FPK} > 80 mA, the following rules for pulse width apply:
   I_{FPK} ≤ 160 mA: Pulse width ≤ 1 ms
   I_{FPK} ≥ 160 mA: Pulse width ≤ 1 μs, period ≥ 20 μS.
2. It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from pin 2 to pin 3 of the HFBR-25X1/25X2/25X4 receivers and from pin 2 to pin 4 of the HFBR-25X3 receiver. Total lead length between both ends of the capacitor and the supply pins should not exceed 20 mm.
3. The propagation delay for one metre of cable is typically 5 ns.
4. $t_D = t_{PLH} - t_{PHL}$.
5. Typical data is at 25° C, V_{CC} = 5 V.
6. Typical propagation delay is measured at P_R = -15 dBm.
7. Estimated typical link life expectancy at 40° C exceeds 10 years at 60 mA.
8. Pulsed LED operation at I_F > 80 mA will cause increased link t_{PLH} propagation delay time. This extended t_{PLH} time contributes to increased pulse width distortion of the receiver output signal.
9. Pins 5 and 8 of both the transmitter and receiver are for mounting and retaining purposes only. Do not electrically connect pin 5 and/or pin 8.

Versatile Link Design Considerations

Simple interface circuits for 5 MBd, 1 MBd and 40 kBd applications are shown in Figure 1. The value of the transmitter drive current depends upon the desired link distance. This is shown in Figures 2a through 2f. After selecting a value of transmitter drive current, I_F, the value of R1 can be determined with the aid of Figures 1a, 1b and 1d. Note that the 5 MBd and 40 kBd Versatile Links can have an overdrive and underdrive limit for the chosen value of I_F while the 1 MBd Versatile Link has only an underdrive limit. Dotted lines in Figures 2a through 2f represent pulsed operation for extended link distance requirements. For the 1 MBd interface circuit, the R1C1 time constant must be > 75 ns. Conditions described in Note 1 must be met for pulsed operation. Refer to Note 8 for performance comments when pulsed operation is used.

All specifications are guardbanded for worst case conditions between 0 to 70 degrees centigrade. All tolerances and variations (including end-of-life transmitter power, receiver sensitivity, coupling variances, connector and cable variations) are taken into account.

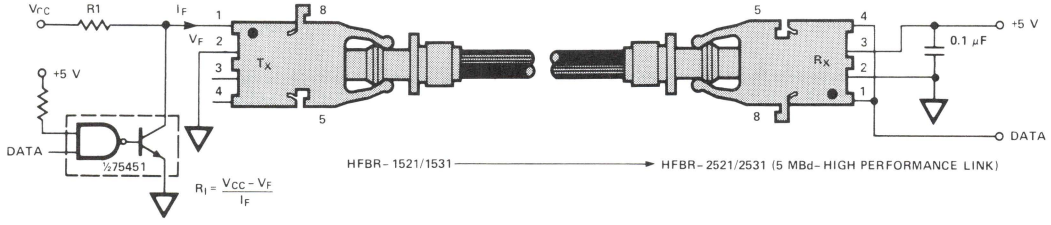
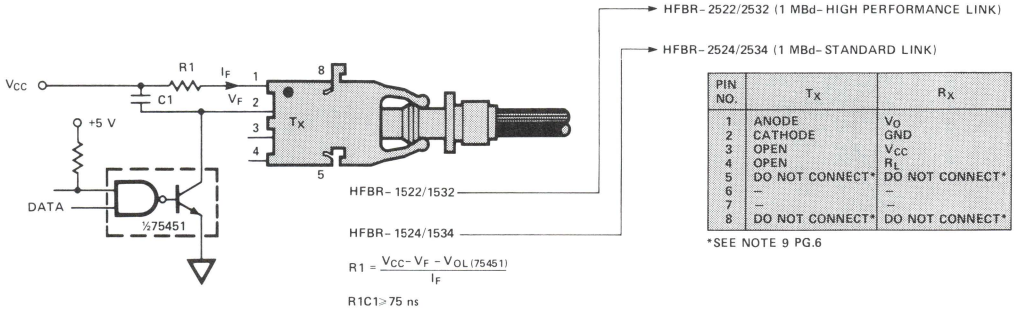


Figure 1a. Typical 5 MBd Interface Circuit;

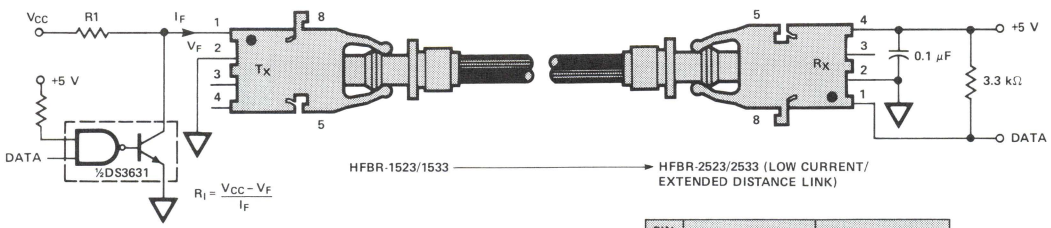


1b. Required 1 MBd Interface Circuit;

PIN NO.	Tx	Rx
1	ANODE	V_O
2	CATHODE	GND
3	OPEN	V_{CC}
4	OPEN	R_L
5	DO NOT CONNECT*	DO NOT CONNECT*
6	–	–
7	–	–
8	DO NOT CONNECT*	DO NOT CONNECT*

*SEE NOTE 9 PG.6

1c. Electrical Pin Assignments for 5 MBd and 1 MBd Transmitters and Receivers



1d. Typical 40 kBd Interface Circuit;

PIN NO.	Tx	Rx
1	ANODE	V_O
2	CATHODE	GND
3	OPEN	OPEN
4	OPEN	V_{CC}
5	DO NOT CONNECT*	DO NOT CONNECT*
6	–	–
7	–	–
8	DO NOT CONNECT*	DO NOT CONNECT*

*SEE NOTE 9 PG.6

1e. Electrical Pin Assignments for 40 kBd Transmitters and Receivers

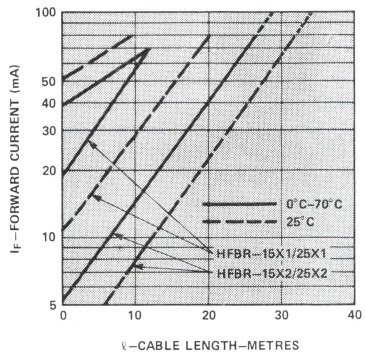


Figure 2a. Guaranteed System Performance for the HFBR-15X1/25X1 and HFBR-15X2/25X2 Links with Standard Cable

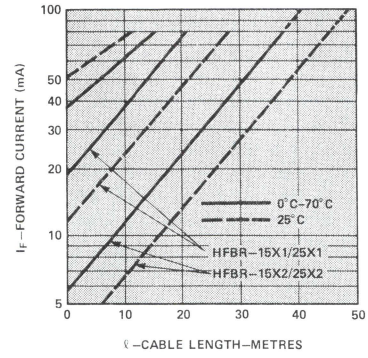


Figure 2b. Guaranteed System Performance for the HFBR-15X1/25X1 and HFBR-15X2/25X2 Links with Improved Cable

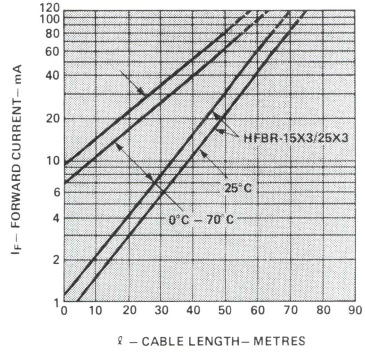


Figure 2c. Guaranteed System Performance for the HFBR-15X3/25X3 Link with Standard Cable

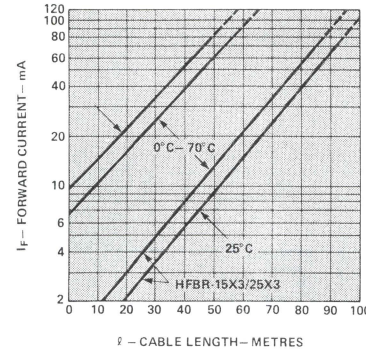


Figure 2d. Guaranteed System Performance for the HFBR-15X3/25X3 Link with Improved Cable

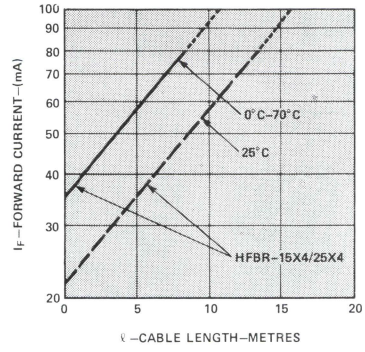


Figure 2e. Guaranteed System Performance for the HFBR-15X4/25X4 Link with Standard Cable

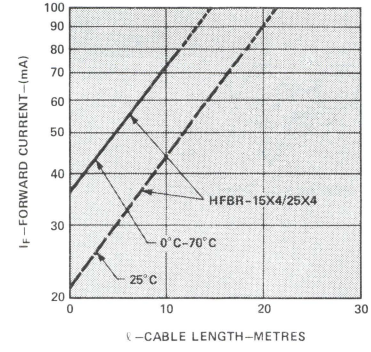


Figure 2f. Guaranteed System Performance for the HFBR-15X4/25X4 Link with Improved Cable

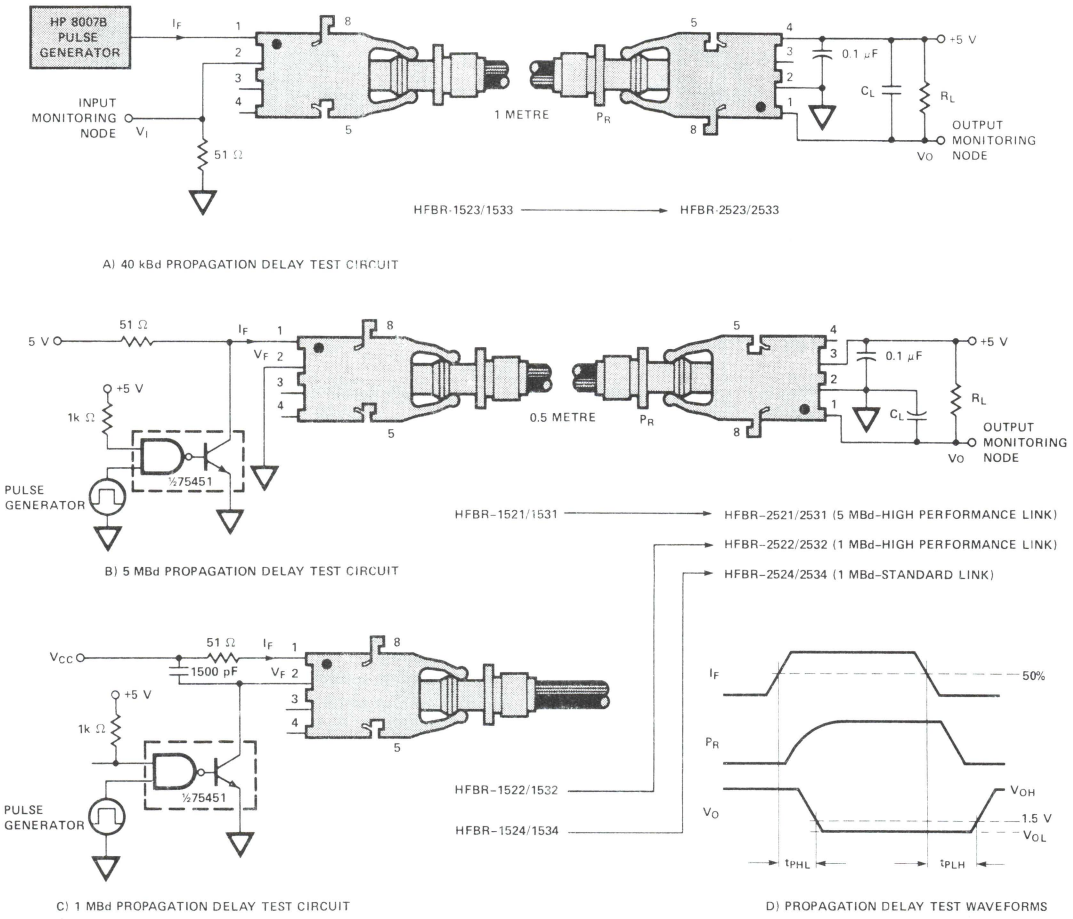


Figure 3. Propagation Delay Test Circuits and Waveforms: a) 40 kBd, b) 5 MBd, c) 1 MBd, d) Test Waveforms

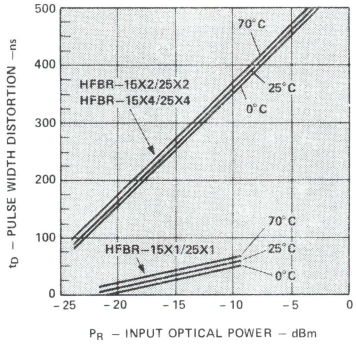


Figure 4. Typical HFBR-15X1/25X1, HFBR-15X2/25X2 and HFBR-15X4/25X4 Link Pulse Width Distortion vs. Optical Power

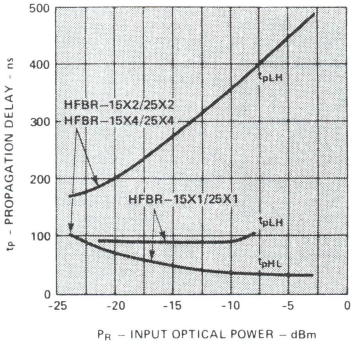


Figure 5. Typical HFBR-15X1/25X1, HFBR-15X2/25X2 and HFBR-15X4/25X4 Link Propagation Delay vs. Optical Power

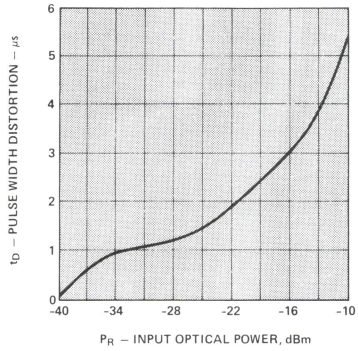


Figure 6. Typical HFBR-15X3/25X3 Link Pulse Width Distortion vs. Optical Power

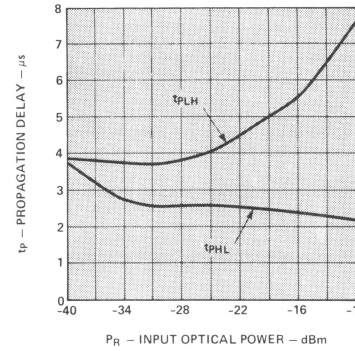


Figure 7. Typical HFBR-15X3/25X3 Link Propagation Delay vs. Optical Power

Versatile Link Photo Interrupter

20 KHz (40 kBd) LINK, 500 kHz (1 MBd) LINK

Versatile Link may be used as a photo-interrupter in optical switches, shaft position sensors, velocity sensors, position sensors, and other similar applications. This link is particularly useful where high voltage, electrical noise, or explosive environments prohibit the use of electromechanical or optoelectronic sensors. The 20 kHz (40 kBd) transmitter/receiver pair has an optical power budget of 25 dB. The 500 kHz (1 MBd) transmitter/receiver pair has an optical power budget of 10 dB. Total system losses (cable attenuation, air gap loss, etc.) must not exceed the link optical power budget.

RECOMMENDED OPERATING CONDITIONS

Recommended operating conditions are identical to those of the Low Current/Extended Distance and High Performance 1 MBd links. Refer to page 5.

SYSTEM PERFORMANCE

These specification apply when using Standard and Improved cable and, unless otherwise specified, under recommended operating conditions. Refer to the appropriate link data on pages 7 and 8 for additional design information.

Parameter	Min.	Typ.[1]	Max.	Units	Conditions	Ref.
HFBR-15X3/25X3						
Max. Count Frequency	dc		20	kHz		
Optical Power Budget	25.4			dB	I_{FPK} = 60 mA, 0-70° C	Note 2
	27.8	34		dB	I_{FPK} = 60 mA, 25° C	
HFBR-15X2/25X2						
Max. Count Frequency	dc		500	kHz		
Optical Power Budget	10.4			dB	I_{FPK} = 60 mA, 0-70° C	Note 2
	12.8	15.6		dB	I_{FPK} = 60 mA, 25° C	

Notes:

1. Typical data is at 25°C, V_{CC} = 5 V.
2. Optical Power Budget = P_T min. - P_R (L) min. Refer to pages 11-14 for additional design information.

Photo Interrupter Link Design Considerations

The fiber optic Transmitter/Receiver pair is intended for applications where the photo interrupter must be physically separated from the optoelectronic emitter and detector. This separation would be useful where high voltage, electrical noise or explosive environments prohibit the use of electronic devices. To ensure reliable long term operation, link design for this application should operate with an ample optical power margin $\alpha_M \geq 3$ dB, since the exposed fiber ends are subject to environmental contamination that will increase the optical attenuation of the slot with time. A graph of air gap separation versus attentuation for clean fiber ends with minimum radial error ≤ 0.127 mm (0.005 inches) and angular error ($\leq 3.0°$) is provided in Figure 1.

The following equations can be used to determine the transmitter output power, P_T, for both the overdrive and underdrive cases. Overdrive is defined as a condition where excessive optical power is delivered to the receiver. The first equation calculates, for a predetermined link length and slot attenuation, the maximum P_T in order not to overdrive the receiver. The second equation defines the minimum P_T allowed for link operation to prevent underdrive condition from occurring.

$$P_T\,(MAX) - P_R\,(MAX) \leq \alpha_{O\,MIN}\,\ell + \alpha_{SLOT} \qquad \text{Eq. 1}$$

$$P_T\,(MIN) - P_{RL}\,(MIN) \geq \alpha_{O\,MAX}\,\ell + \alpha_{SLOT} + \alpha_M \qquad \text{Eq. 2}$$

Once P_T (MIN) has been determined in the second equation for a specific link length (ℓ), slot attenuation (α_{SLOT}) and margin (α_M), Figure 2 can then be used to find I_F.

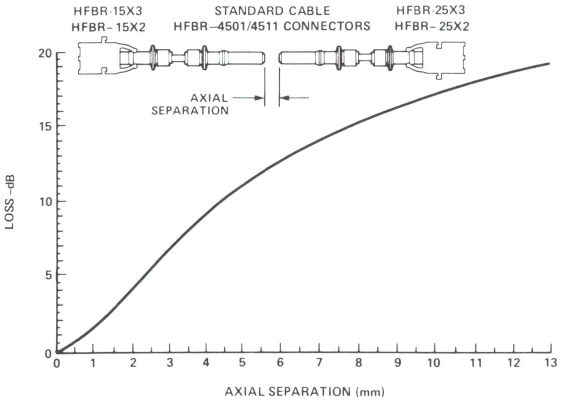


Figure 1. Typical Loss vs. Axial Separation

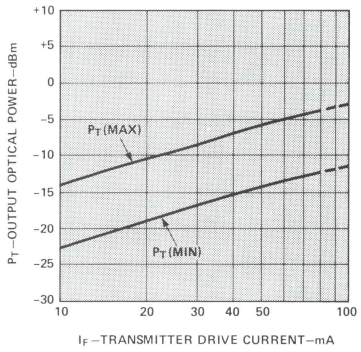


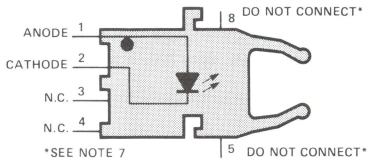
Figure 2. Typical HFBR-15X3/15X2 Optical Power vs. Transmitter I_F (0-70°C)

Versatile Link Transmitters

HFBR-1521/1531 (5 MBd - High Performance)
HFBR-1522/1532 (1 MBd - High Performance)
HFBR-1523/1533 (40 kBd - Low Current/Extended Distance)
HFBR-1524/1534 (1 MBd - Standard)

Versatile Link transmitters incorporate a 660 nanometre LED in a gray horizontal or vertical housing for the HFBR-15X1/2/4 transmitters or a black horizontal or vertical housing for the HFBR-15X3 receiver. The transmitters can be easily interfaced to standard TTL logic. The optical output power of the HFBR-152X/153X series is specified at the end of 0.5 m of cable. The mechanical and electrical pin spacing and connections are identical for both the horizontal and vertical packages.

HFBR-152X/153X SERIES TRANSMITTERS



Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Operating Temperature		T_A	0	+70	°C	
Lead Soldering Cycle	Temp.			260	°C	Note 1
	Time			10	sec.	
Peak Forward Input Current		I_{FPK}		1000	mA	Note 2
DC Forward Input Current		I_{FDC}		80	mA	
Reverse Input Voltage		V_R		5	V	

Electrical/Optical Characteristics 0°C to +70°C Unless Otherwise Specified

Parameter		Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Transmitter Output Optical Power	HFBR-15X1	P_T	-16.5		-7.6	dBm	I_F = 60 mA, 0-70°C	Fig. 2
			-14.3		-8.0	dBm	I_F = 60 mA, 25°C	Notes 3, 4
	HFBR-15X2 and HFBR-15X3	P_T	-13.6		-4.5	dBm	I_F = 60 mA, 0-70°C	
			-11.2		-5.1	dBm	I_F = 60 mA, 25°C	
	HFBR-15X3	P_T	-35.5			dBm	I_F = 2 mA, 0-70°C	
	HFBR-15X4	P_T	-17.8		-4.5	dBm	I_F = 60 mA, 0-70°C	
			-15.5		-5.1	dBm	I_F = 60 mA, 25°C	
Output Optical Power Temperature Coefficient		$\frac{\Delta P_T}{\Delta T}$		-0.85		%/°C		
Peak Emission Wavelength		λ_{PK}		660		nm		
Forward Voltage		V_F	1.45	1.67	2.02	V	I_F = 60 mA	
Forward Voltage Temperature Coefficient		$\frac{\Delta V_F}{\Delta T}$		-1.37		mV/°C		Fig. 1
Effective Diameter		D_T		1		mm		
Numerical Aperture		N.A.		0.5				
Reverse Input Breakdown Voltage		V_{BR}	5.0	11.0		V	I_F = -10 μA, T_A = 25°C	
Diode Capacitance		C_O		86		pF	V_F = 0, f = 1 MHz	
Rise Time		t_r		80		ns	10% to 90%, I_F = 60 mA	Note 6
Fall Time		t_f		40		ns		

Notes:

1. 1.6 mm below seating plane.
2. 1 μs pulse, 20 μs period.
3. Measured at the end of 0.5 m Standard Fiber Optic Cable with large area detector.
4. Optical power, P (dBm) = 10 Log [P (μW)/1000 μW].
5. Typical data is at 25°C.
6. Rise and fall times are measured with a voltage pulse driving the transmitter and a series connected 50 Ohm load. A wide bandwidth optical to electrical waveform analyzer (transducer), terminated to a 50 Ohm input of a wide bandwidth oscilloscope, is used for this response time measurement.
7. Pins 5 and 8 of the transmitter are for mounting and retaining purposes only. Do not electrically connect pin 5 and/or pin 8.

WARNING: When viewed under some conditions, the optical port of the Transmitter may expose the eye beyond the Maximum Permissible Exposure recommended in ANSI Z-136-1, 1981. Under most viewing conditions there is no eye hazard.

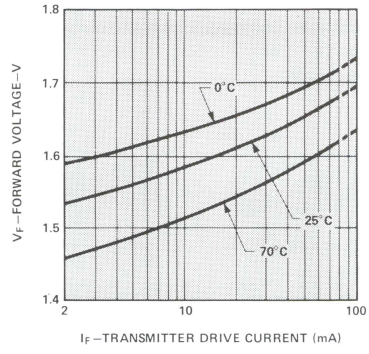


Figure 1. Typical Forward Voltage vs. Drive Current for HFBR-152X/153X Series Transmitters

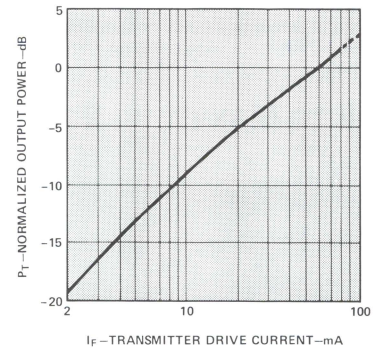


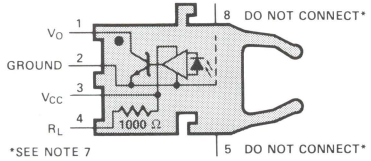
Figure 2. Normalized HFBR-152X/153X Series Transmitter Typical Output Optical Power vs. Drive Current

Versatile Link Receivers

HFBR-2521/2531 (5 MBd - High Performance)
HFBR-2522/2532 (1 MBd - High Performance)
HFBR-2524/2534 (1 MBd - Standard)

The blue plastic Versatile Link receivers feature a shielded, integrated photodetector and a wide bandwidth DC amplifier for high EMI immunity. A Schottky clamped open-collector output transistor allows interfacing to common logic families and enables "wired-OR" circuit designs. The open collector output is specified up to 18 V. An integrated 1000 ohm resistor internally connected to V_{CC} may be externally connected to provide a pull-up for ease of use with +5 V logic. Under pulsed LED current operation (I_F > 80 mA), the combination of a high optical power level and the optical falling edge of the LED transmitter will result in increased pulse width distortion of the receiver output signal.

HFBR-25X1/25X2/25X4 RECEIVER



Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Operating Temperature		T_A	0	+70	°C	
Lead Soldering Cycle	Temp.			260	°C	Note 1
	Time			10	sec.	
Supply Voltage		V_{CC}	-0.5	7	V	Note 6
Output Collector Current		I_O		25	mA	
Output Collector Power Dissipation		P_{OD}		40	mW	
Output Voltage		V_O	-0.5	18	V	
Pullup Voltage		V_{RL}	-0.5	V_{CC}	V	

Electrical/Optical Characteristics

0°C to +70°C, 4.75 V ≤ V_{CC} ≤ 5.25 V Unless Otherwise Specified

Parameter		Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Receiver Input Optical Power Level for Logic "0"	HFBR-2521 and HFBR-2531	$P_{R(L)}$	-21.6		-9.5	dBm	0-70°C, V_{OL} = 0.5 V, I_{OL} = 8 mA	Notes 2, 3, 8
			-21.6		-8.7	dBm	25°C, V_{OL} = 0.5 V, I_{OL} = 8 mA	
	HFBR-2522 and HFBR-2532	$P_{R(L)}$	-24			dBm	0-70°C, V_{OL} = 0.5 V, I_{OL} = 8 mA	Notes 2, 3, 8, 9
			-24			dBm	25°C, V_{OL} = 0.5 V, I_{OL} = 8 mA	
	HFBR-2524 and HFBR-2534	$P_{R(L)}$	-20			dBm	0-70°C, V_{OL} = 0.5 V, I_{OL} = 8 mA	Notes 2, 3, 8, 9
			-20			dBm	25°C, V_{OL} = 0.5 V, I_{OL} = 8 mA	
Input Optical Power Level for Logic "1"		$P_{R(H)}$			-43	dBm	V_{OH} = 5.25 V, I_{OH} ≤ 250 μA	Note 2
High Level Output Current		I_{OH}		5	250	μA	V_O = 18 V, P_R = 0	Note 4
Low Level Output Voltage		V_{OL}		0.4	0.5	V	I_{OL} = 8 mA, P_R = $P_{R(L)MIN}$	Note 4
High Level Supply Current		I_{CCH}		3.5	6.3	mA	V_{CC} = 5.25 V, P_R = 0 μW	Note 4
Low Level Supply Current		I_{CCL}		6.2	10	mA	V_{CC} = 5.25 V, P_R = -12.5 dBm	Note 4
Effective Diameter		D_R		1		mm		
Numerical Aperture		N.A.$_R$		0.5				
Internal Pull-Up Resistor		R_L	680	1000	1700	Ohms		

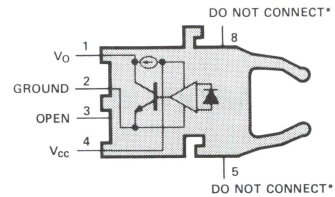
Notes:
1. 1.6 mm below seating plan.
2. Optical flux, P (dBm) = 10 Log [P (μW)/1000 μW].
3. Measured at the end of Fiber Optic Cable with large area detector. detector.
4. R_L is open.
5. Typical data is at 25° C, V_{CC} = 5 V.
6. It is essential that a bypass capacitor 0.01 μF to 0.1 μF be connected from pin 2 to pin 3 of the receiver. Total lead length between both ends of the capacitor and the pins should not exceed 20 mm.
7. Pins 5 and 8 of both the transmitter and receiver are for mounting and retaining purposes only. Do not electrically connect pin 5 and/or pin 8.
8. Pulsed LED operation at I_F > 80 mA will cause increased link t_{PLH} propagation delay time. This extended t_{PLH} time contributes to increased pulse width distortion of the receiver output signal.
9. The LED driver circuit of Figure 1b on page 7 (Link Design Considerations) is required for 1 MBd operation of the HFBR-2522/2532/2524/2534.

High Sensitivity Receiver

HFBR-25X3

The blue plastic HFBR-25X3 Receiver module has a sensitivity of -39 dBm. It features an integrated photodector and DC amplifier for high EMI immunity. The output is an open collector with a 150 μA internal current source pull-up and is compatible with TTL/LSTTL and most CMOS logic families. For minimum rise time add an external pull-up resistor of at least 3.3K ohms. V_{CC} must be greater than or equal to the supply voltage for the pull-up resistor.

HFBR-25X3 RECEIVER



*SEE NOTE 8

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Operating Temperature		T_A	0	+70	°C	
Lead Soldering Cycle	Temp			260	°C	Note 1
	Time			10	sec	
Supply Voltage		V_{CC}	-0.5	7	V	Note 7
Output Collector Current (Average)		I_O	-1	5	mA	
Output Collector Power Dissipation		P_{OD}		25	mW	
Output Voltage		V_O	-0.5	V_{CC}	V	

Electrical/Optical Characteristics 0° C to +70° C, 4.5 ≤ V_{CC} ≤ 5.5 Unless Otherwise Specified

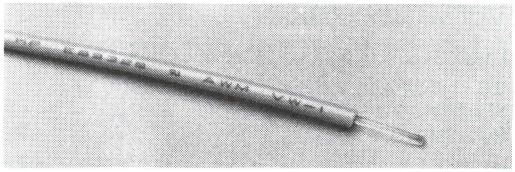
Parameter		Symbol	Min.	Typ. (5)	Max.	Units	Conditions	Ref.
Receiver Input Optical Power Level for Logic "0"	HFBR-2523 and HFBR-2533	$P_{R(L)}$	-39		-13.7	dBm	0-70° C, $V_O = V_{OL}$ I_{OL} = 3.2 mA	Note 2, 3, 4
			-39		-13.3	dBm	25° C, $V_O = V_{OL}$ I_{OL} = 3.2 mA	
Input Optical Power Level for Logic "1"		$P_{R(H)}$			-53	dBm	V_{OH} = 5.5V, $I_{OH} \leq 40$ μA	Note 2
High Level Output Voltage		V_{OH}	2.4			V	I_{OH} = -40 μA, P_R = 0 μW	
Low Level Output Voltage		V_{OL}			0.4	V	I_{OL} = 3.2 mA, $P_R = P_{RL\ MIN}$	Note 6
High Level Supply Current		I_{CCH}		1.2	1.9	mA	V_{CC} = 5.5V, P_R = 0 μW	
Low Level Supply Current		I_{CCL}		2.9	3.7	mA	V_{CC} = 5.5V, $P_R \geq P_{RL\ (MIN)}$	Note 6
Effective Diameter		D_R		1		mm		
Numerical Aperture		N.A.R		0.5				

Notes:
1. 1.6 mm below seating plan.
2. Optical flux, P (dBm) = 10 Log P (μW)/1000 μW.
3. Measured at the end of Fiber Optic Cable with large area detector.
4. Because of the very high sensitivity of the HFBR-25X3, the digital output may switch in response to ambient light levels when a cable is not occupying the receiver optical port. The designer should take care to filter out signals from this source if they pose a hazard to the system.
5. Typical data is at 25° C, V_{CC} = 5 V.
6. Including current in 3.3 K pull-up resistor.
7. It is recommended that a bypass capacitor 0.01 μF to 0.1 μF ceramic be connected from pin 2 to pin 4 of the receiver.
8. Pins 5 and 8 are for mounting and retaining purposes only. Do not electrically connect pin 5 and/or pin 8.

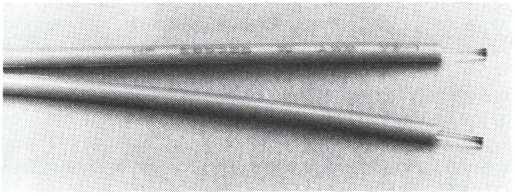
Plastic Fiber Optic Cable

Simplex Fiber Optic Cable is constructed of a single step index plastic fiber sheathed in a PVC jacket. Duplex Fiber Optic Cable has two plastic fibers, each in a cable of construction similar to the Simplex Cable, joined with a web. The individual channels are identified by a marking on one channel of the cable. The Improved Fiber Optic Cable is identical to the Standard Cable except that the attenuation is lower.

These cables are UL recognized components and pass UL VW-1 flame retardancy specification. Safe cable properties in flammable environments, along with non-conductive electrical characteristics of the cable may make the use of conduit unnecessary. Plastic cable is available unconnectored or connectored. Refer to pages 23 and 24 for part numbers.



SIMPLEX CABLE



DUPLEX CABLE

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Installation Temperature		T_I	-20	+70	°C	
Short Term Tensile Force	Single Channel	F_T		50	N	Note 1
	Dual Channel	F_T		100	N	
Short Term Bend Radius		r	10		mm	Note 2
Long Term Bend Radius		r	35		mm	
Long Term Tensile Load		F_T		1	N	
Flexing				1000	Cycles	Note 3
Impact		m		0.5	Kg	Note 4
		h		150	mm	

Electrical/Optical Characteristics 0°C to +70°C Unless Otherwise Specified

Parameter		Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Cable Attenuation	Standard Cable	α_o	0.19	0.31	0.43	dB/m	Source is HFBR-152X/153X (660 nm), ℓ = 20 m	Note 7
	Improved Cable		0.19	0.25	0.31			
Numerical Aperture		N.A.		0.5			$\ell > 2$ m	
Diameter, Core		D_C		1.0		mm		
Diameter, Jacket		D_J		2.2		mm	Simplex Cable	
Travel Time Constant		ℓ/v		5.0		nsec/m		Note 6
Mass per Unit Length/Channel		m/ℓ		4.6		g/m	Without Connectors	
Cable Leakage Current		I_L		12		nA	50 kV, ℓ = 0.3 m	

Notes:

1. Less than 30 minutes.
2. Less than 1 hour, non-operating.
3. 90° bend on 10 mm radius mandrel.
4. Tested at 1 impact according to MIL-STD-1678, Method 2030, Procedure 1.
5. Typical data is at 25°C.
6. Travel time constant is the reciprocal of the group velocity for propagation of optical power. Group velocity is v = c/n, where c is the velocity of light in space (3×10^8 m/s) and n equals effective core index of refraction. Unit length of cable is ℓ.
7. In addition to standard Hewlett-Packard 100% product testing, HP provides additional margin to ensure link performance. Under certain conditions, cable installation and improper connectoring may reduce performance. Contact Hewlett-Packard for recommendations.
8. Improved cable is available in 500 metre spools and in factory-connectored lengths less than 100 metres.

Versatile Link Fiber Optic Connectors

CONNECTORS FEEDTHROUGH/SPLICE POLISHING TOOLS

Versatile Link transmitters and receivers are compatible with three connector styles; simplex, simplex latching, and duplex. All connectors provide a snap-action when mated to Versatile Link components. Simplex connectors are color coded to match with transmitter and receiver color coding. Duplex connectors are keyed so that proper orientation is ensured. When removing a connector from a module, pull at the connector body. Do not pull on the cable alone. The same, quick and simple connectoring technique is used with all connectors and cable. This technique is described on page 18.

Simplex Connector Styles

HFBR-4501/4511 — Simplex

The simplex connector provides a quick and stable connection for applications that require a component to provide retention force of 8 Newtons (1.8 lbs). These connectors are available in colors of gray (HFBR-4501) or blue (HFBR-4511).

HFBR-4503/4513 — Simplex Latching

The simplex latching connector is designed for rugged applications requiring greater retention force, 80 N (18 lbs), than that provided by a simplex connector. When inserting the simplex latching connector into a module, the connector latch mechanism should be aligned with the top surface of the horizontal module, or with the tall vertical side of the vertical module. Misorientation of an inserted latching connector into either module housing will not result in a positive latch. The connector is released by depressing the rear section of the connector lever, and then pulling the connector assembly away from the module housing.

If the cable/connector will be used at elevated operating temperatures or experience frequent and wide temperature cycling effects, the cable/connector attachment can be strengthened by applying a RTV adhesive within the connector. A recommended adhesive is 3M Company product RTV-739. In most applications, use of RTV is unnecessary. The simplex latching connector is available in gray (HFBR-4503) or blue (HFBR-4513).

Duplex Connector HFBR-4506 — Duplex

Duplex connectors provide convenient duplex cable termination and are keyed to prevent incorrect connection. The duplex connector is compatible with dual combinations of identical Versatile Link components (e.g., two horizontal transmitters, two vertical receivers, a horizontal transmitter and a horizontal receiver, etc.). A duplex connector cannot connect to two different packages simultaneously. The duplex connector is an off-white color.

Feedthrough/Splice HFBR-4505/4515 — Adapter

The HFBR-4505/4515 adapter mates two simplex connectors for panel/bulkhead feedthrough of plastic fiber cable. Maximum panel thickness is 4.1 mm (0.16 inch). This adapter can serve as a cable in-line splice using two simplex connectors. The colors of the adapters are gray (HFBR-4505) and blue (HFBR-4515). The adapter is not compatible with the duplex or simplex latching connectors.

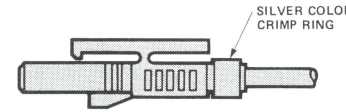
Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	-40	+75	°C	
Operating Temperature	T_A	0	+70	°C	
Nut Torque HFBR-4505/4515	T_N		0.7	N-m	1
			100	OzF-in	

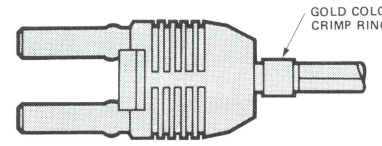
Notes:
1. Recommended nut torque is 0.57 N-m (80 OzF-in).

HFBR-4501 (GRAY)/4511 (BLUE) SIMPLEX CONNECTOR

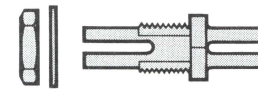
HFBR-4503 (GRAY)/4513 (BLUE) SIMPLEX LATCHING CONNECTOR



HFBR-4506 (PARCHMENT) DUPLEX CONNECTOR

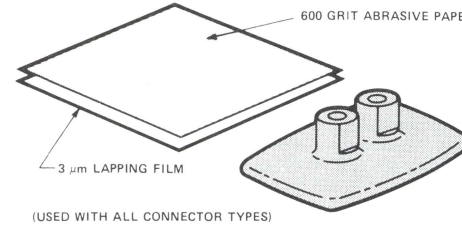


HFBR-4505 (GRAY)/4515 (BLUE) ADAPTER



(USE WITH SIMPLEX CONNECTORS ONLY)

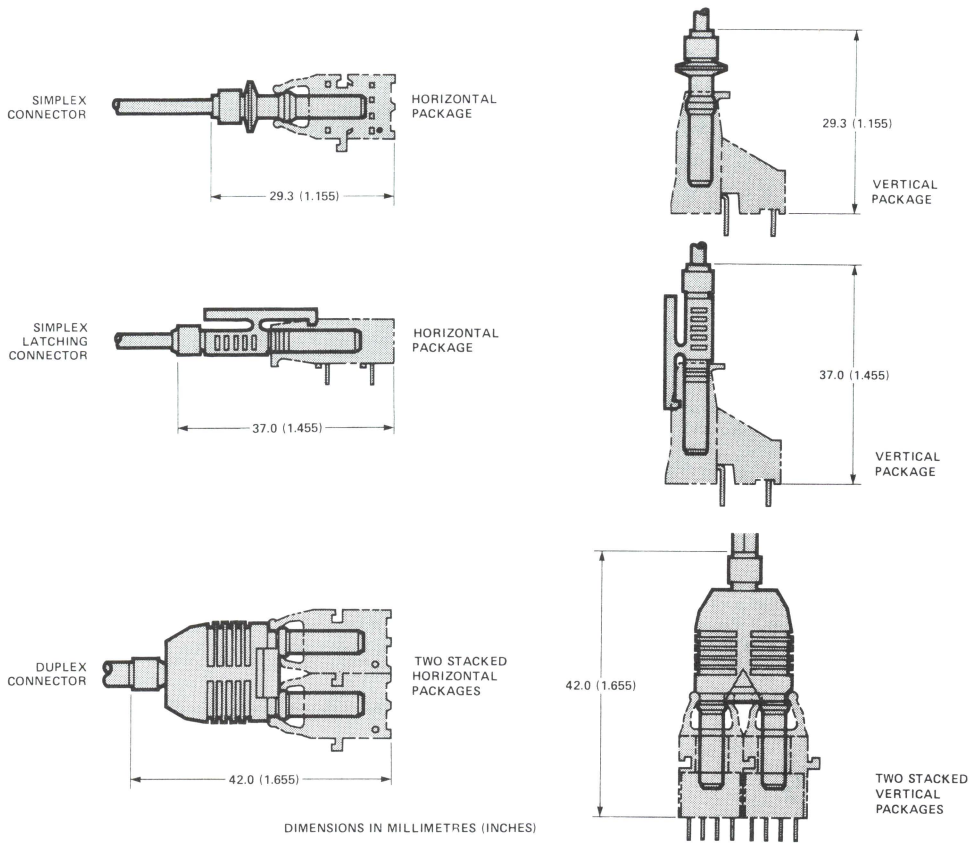
HFBR-4593 POLISHING KIT

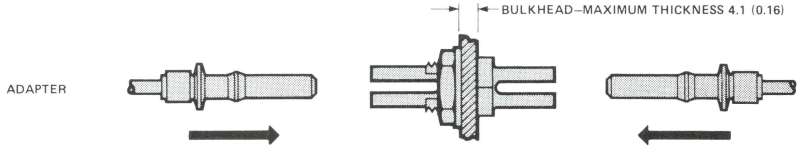


(USED WITH ALL CONNECTOR TYPES)

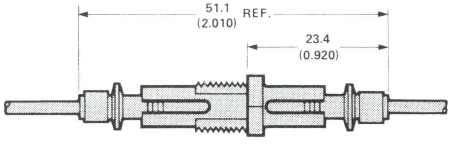
Connector Applications

ATTACHMENT TO HEWLETT-PACKARD HFBR-152X/153X/252X/253X VERSATILE LINK FIBER OPTIC COMPONENTS





BULKHEAD FEEDTHROUGH OR PANEL MOUNTING FOR HFBR-4501/4511 SIMPLEX CONNECTORS



IN-LINE SPLICE FOR HFBR-35XX/36XX FIBER OPTIC CABLE WITH HFBR-4501/4511 SIMPLEX CONNECTORS

Connector Mechanical/Optical Characteristics 25°C Unless Otherwise Specified.

Parameter	Part Number		Symbol	Min.	Typ.	Max.	Units	Ref.
Retention Force Connector to HFBR-152X/153X/252X/253X Modules	Simplex	HFBR-4501/4511	F_{R-C}	7	8		N	Note 4
	Simplex Latching	HFBR-4503/4513		47	80			
	Duplex	HFBR-4506		7	12			
Tensile Force Connector to Cable	Simplex	HFBR-4501/4511	F_T	8.5	22		N	Notes 3, 4
	Simplex Latching	HFBR-4503/4513		8.5	22			
	Duplex	HFBR-4506		14	35			
Adapter Connector to Connector Loss	HFBR-4505/4515 with HFBR-4501/4511		α_{CC}	0.7	1.5	2.8	dB	Notes 1, 5
Retention Force Connector to Adapter	HFBR-4505/4515 with HFBR-4501/4511		F_{R-B}	7	8		N	Note 4
Insertion Force Connector to HFBR-152X/153X/252X/253X Modules	Simplex	HFBR-4501/4511	F_I		8	12	N	Notes 2, 4
	Simplex Latching	HFBR-4503/4513			16	35		
	Duplex	HFBR-4506			13	46		

Notes:

1. Factory polish or field polish per recommended procedure.
2. No perceivable reduction in insertion force was observed after 2000 insertions. Destructive insertion force was typically at 178 N (40 lbs).
3. For applications where frequent temperature cycling over temperature extremes is expected please contact Hewlett-Packard for alternate connectoring techniques.
4. All mechanical forces were measured after units were stored at 70°C for 168 hours and returned to 25°C for one hour.
5. Minimum and maximum limits of α_{CC} are for 0°C to 70°C temperature range. Typical value of α_{CC} is at 25°C.

Connectoring

The following easy procedure describes how to make cable terminations. It is ideal for both field and factory installation. If a high volume connectoring technique is required please contact your Hewlett-Packard sales engineer for the recommended procedure and equipment.

Connectoring the cable is accomplished with the Hewlett-Packard HFBR-4593 Polishing Kit consisting of a Polishing Fixture, 600 grit abrasive paper and 3 micron pink lapping film (3M Company, OC3-14). No adhesive material is needed to secure the cable in the connector, and the connector can be used immediately after polishing. Improved connector to cable attachment can be achieved with the use of a RTV adhesive for frequent, extreme temperature cycling environments or for elevated temperature operation.

Connectors may be easily installed on the cable ends with readily available tools. Materials needed for the terminating procedure are:

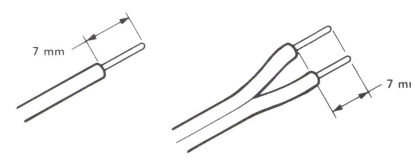
1) Hewlett-Packard Plastic Fiber Optic Cable
2) HFBR-4593 Polishing Kit
3) HFBR-4501/4503 Gray Simplex/Simplex Latching Connector and Silver Color Crimp Ring
4) HFBR-4511/4513 Blue Simplex/Simplex Latching Connector and Silver Color Crimp Ring
5) HFBR-4506 Parchment Duplex Connector and Gold Color Crimp Ring
6) Industrial Razor Blade or Wire Cutters
7) 16 Gauge Latching Wire Strippers
8) Crimp Tool, AMP 90364-2

Step 1

The zip cord structure of the duplex cable permits easy separation of the channels. The channels should be separated approximately 50 mm (2.0 in.) back from the ends to permit connectoring and polishing.

After cutting the cable to the desired length, strip off approximately 7 mm (0.3 in.) of the outer jacket with the 16 gauge wire strippers. Excess webbing on duplex cable may have to be trimmed to allow the simplex or simplex latching connector to slide over the cable.

When using the duplex connector and duplex cable, the separated duplex cable must be stripped to equal lengths on each cable. This allows easy and proper seating of the cable into the duplex connector.



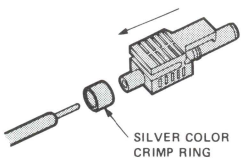
Step 2

Place the crimp ring and connector over the end of the cable; the fiber should protrude about 3 mm (0.12 in.) through the end of the connector. Carefully position the ring so that it is entirely on the connector and then crimp the ring in place with the crimping tool. One crimp tool is used for all connector crimping requirements.

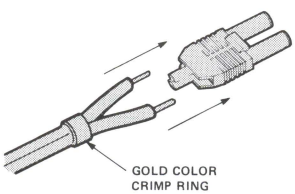
Note: *Place the gray connector on the cable end to be connected to the transmitter and the blue connector on the cable end to be connected to the receiver to maintain the color coding (both connectors are the same mechanically). For duplex connector and duplex cable application, align the color coded side of the cable with the appropriate ferrule of the duplex connector in order to match connections to the respective optical ports. The simplex connector crimp ring (silver color) cannot be used with the duplex connector. The duplex connector crimp ring (gold color) cannot be used with the simplex or simplex latching connectors.*

SIMPLEX

SIMPLEX LATCHING



DUPLEX



Step 3

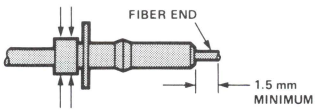
Any excess fiber protuding from the connector end may be cut off; however, the trimmed fiber should extend at least 1.5 mm (0.06 in.) from the connector end.

Insert the connector fully into the polishing fixture with the trimmed fiber protruding from the bottom of the fixture.

This plastic polishing fixture can be used to polish two simplex connectors or two simplex latching connectors simultaneously, or one duplex connector.

Note: *The four dots on the bottom of the polishing fixture are wear indicators. Replace the polishing fixture when any dot is no longer visible.*

Place the 600 grit abrasive paper on a flat smooth surface. Pressing down on the connector, polish the fiber and the connector using a figure eight pattern of strokes until the connector is flush with the bottom of the polishing fixture. Wipe the connector and fixture with a clean cloth or tissue.

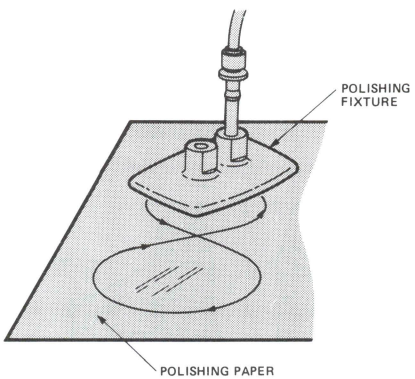


Step 4

Place the flush connector and polishing fixture on the dull side of the 3 micron pink lapping film and continue to polish the fiber and connector for approximately 25 strokes. The fiber end should be flat, smooth and clean.

The cable is now ready for use.

Note: *Use of the pink lapping film fine polishing step results in approximately 2 dB improvement in coupling performance of either a transmitter-receiver link or a bulkhead/splice over 600 grit polish alone. This fine polish is comparable to Hewlett-Packard factory polish. The fine polishing step may be omitted where an extra 2 dB of optical power is not essential, as with short link lengths. Proper polishing of the tip of the fiber/connector face results in a tip diameter between 2.8 mm (0.110 in.) minimum and 3.2 mm (0.125 in.) maximum.*



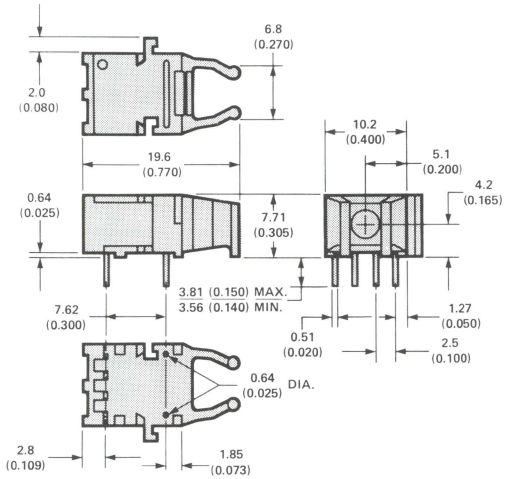
For simultaneous multiple connector polishing techniques please contact Hewlett-Packard.

Versatile Link Mechanical Dimensions

All dimensions in mm (inches).
All dimensions ±0.25 mm unless otherwise specified.

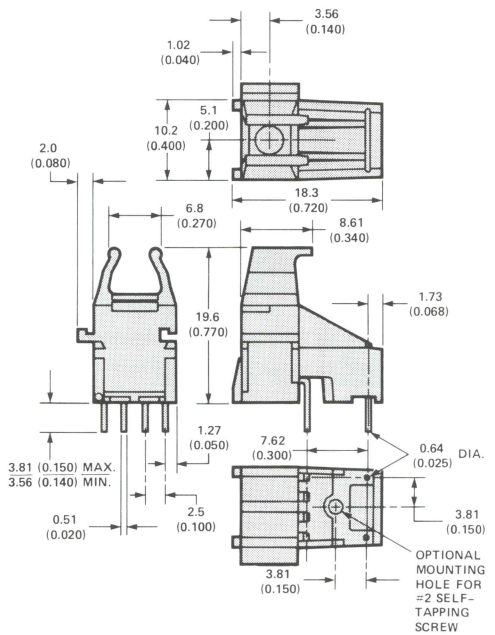
HORIZONTAL MODULES

HFBR-1521/1522/1523/1524 (GRAY)
HFBR-2521/2522/2523/2524 (BLUE)



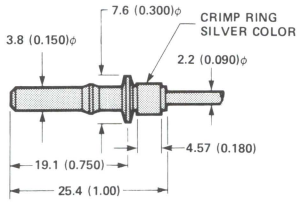
VERTICAL MODULES

HFBR-1531/1532/1533/1534 (GRAY)
HFBR-2531/2532/2533/2534 (BLUE)



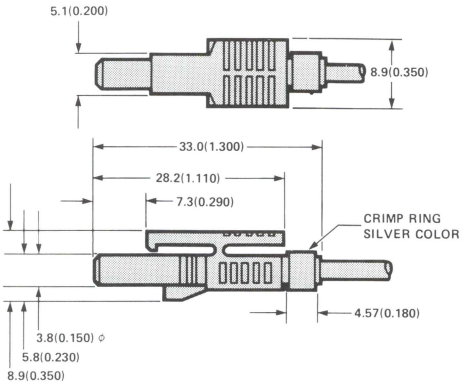
(METRIC EQUIVALENT M2.2 x 0.45)

HFBR-4501 (GRAY)/4511 (BLUE) SIMPLEX CONNECTOR

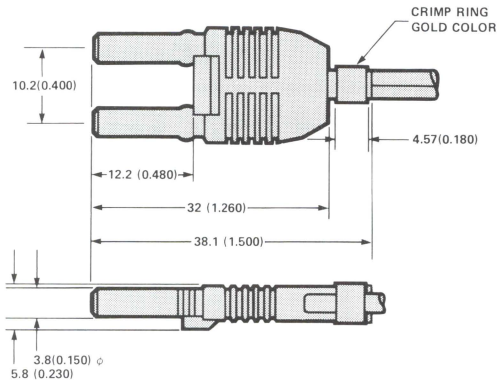


CONNECTORS DIFFER ONLY IN COLOR

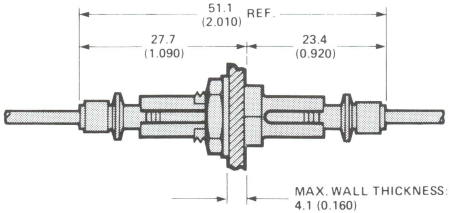
HFBR-4503 (GRAY)/4513 (BLUE) SIMPLEX LATCHING CONNECTOR



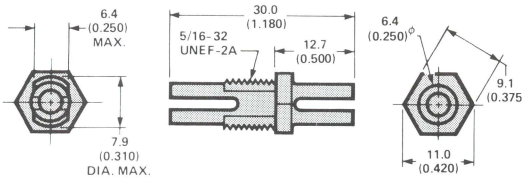
HFBR-4506 (PARCHMENT) DUPLEX CONNECTOR



BULKHEAD FEEDTHROUGH WITH TWO HFBR-4501/4511 CONNECTORS



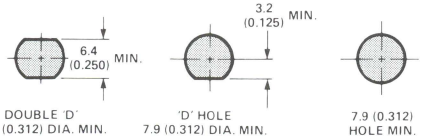
HFBR-4505 (GRAY)/4515 (BLUE) ADAPTERS



ADAPTERS DIFFER ONLY IN COLOR

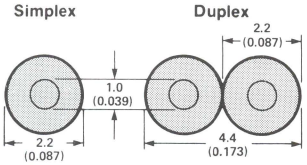
PANEL MOUNTING — BULKHEAD FEEDTHROUGH

THREE TYPES OF PANEL/BULKHEAD HOLES CAN BE USED.



DIMENSIONS IN mm (INCHES)
ALL DIMENSIONS ± 0.2 mm UNLESS NOTED.

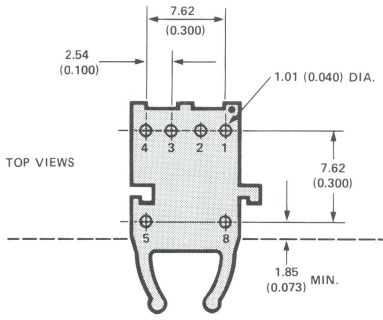
FIBER OPTIC CABLE DIMENSIONS



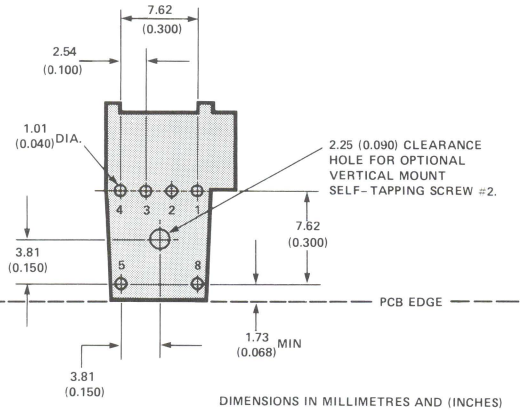
DIMENSIONS IN MILLIMETRES AND (INCHES)

Versatile Link Printed Circuit Board Layout Dimensions

HORIZONTAL MODULE



VERTICAL MODULE



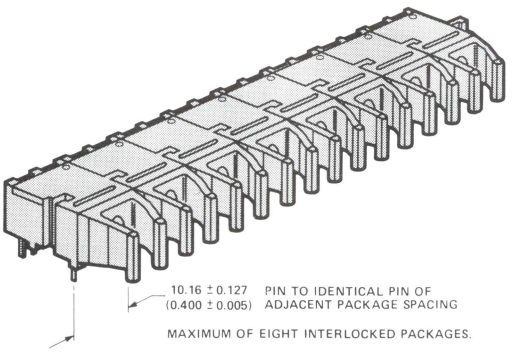
DIMENSIONS IN MILLIMETRES AND (INCHES)

ELECTRICAL PIN FUNCTIONS

PIN NO.	TRANSMITTERS HFBR-15XX	RECEIVERS EXCLUDING HFBR-25X3	RECEIVER HFBR-25X3
1	ANODE	V_O	V_O
2	CATHODE	GROUND	GROUND
3	OPEN	V_{CC}	OPEN
4	OPEN	R_L	V_{CC}
5	DO NOT CONNECT	DO NOT CONNECT	DO NOT CONNECT
6	DO NOT CONNECT	DO NOT CONNECT	DO NOT CONNECT

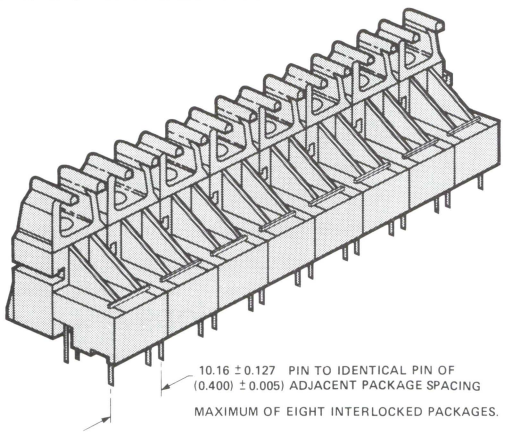
Interlocked (Stacked) Assemblies

STACKING HORIZONTAL MODULES

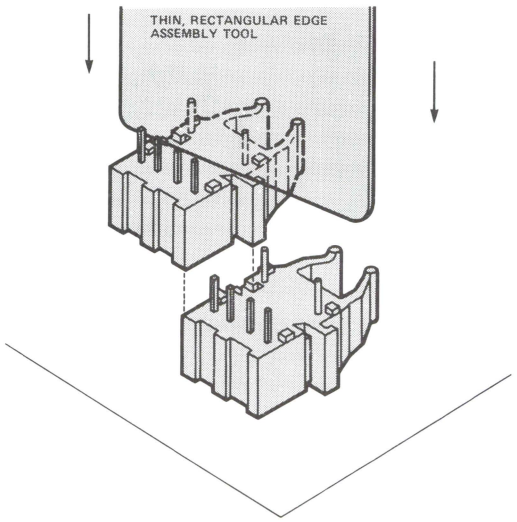


Recommended stacking assembly of horizontal packages is easily accomplished by placing units upside down with pins facing upward. Initially engage the interlocking mechanism by sliding the L bracket body from above into the L slot body of the lower package. Lay the partially interlocked units on a flat surface and push down with a thin, rigid, rectangular edged object to bring all stacked units into uniform alignment. This technique prevents potential harm that could occur to fingers and hands of assemblers from the package pins. Refer to Figure 1 below that illustrates this assembly. Stacked horizontal packages can be disengaged should there be a need to do so. Repeated stacking and unstacking causes no damage to individual units.

STACKING VERTICAL MODULES



Recommended stacking of vertical packages is to hold two vertical units, one in each hand, with the pins facing away from the assembler and the optical ports located in the bottom front of each unit. Engage completely, the L bracket unit from above into the lower L slot unit. Package to package alignment is easily insured by laying the full, flat, bottom side of the assembled units onto a flat surface pushing with a finger the two packages into complete, parallel alignment. The thin rectangular edged tool, used for horizontal package alignment, is not needed with the vertical packages. Stacked vertical packages can be disengaged should there be a need to do so. Repeated stacking and unstacking causes no damage to individual units.



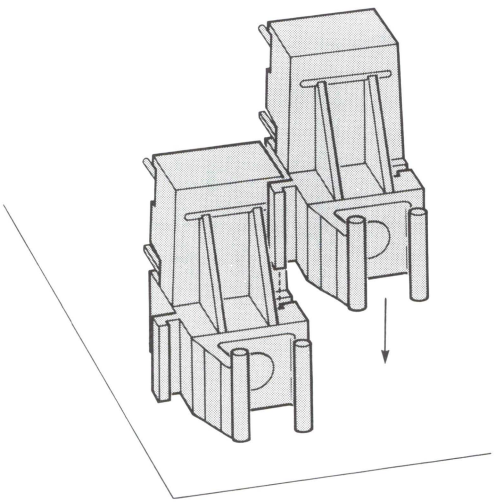


Figure 1. Interlocked (Stacked) Horizontal or Vertical Packages.

Versatile Link Polishing Kit

Contents: a) One polishing tool.
b) One piece, 600 grit abrasive paper: 3M Company.
c) One piece, 3 μm lapping film: 3M company, OC3-14.

Component Selection Guide

TRANSMITTERS (T_X)/RECEIVERS (R_X) Pages 11/14

Versatile Link	Unit	Horizontal Modules	Vertical Modules
5 MBd High Performance	T_X	HFBR-1521	HFBR-1531
1 MBd High Performance	T_X	HFBR-1522	HFBR-1532
40 kBd Low Current/ Extended Distance	T_X	HFBR-1523	HFBR-1533
1 MBd Standard	T_X	HFBR-1524	HFBR-1534
5 MBd High Performance	R_X	HFBR-2521	HFBR-2531
1 MBd High Performance	R_X	HFBR-2522	HFBR-2532
40 kBd Low Current/ Extended Distance	R_X	HFBR-2523	HFBR-2533
1 MBd Standard	R_X	HFBR-2524	HFBR-2534

CABLES Page 15

Connectored Standard Plastic Fiber Optic Cable Simplex Standard Cable		
Standard Simplex Connectors	**Latching Simplex Connectors**	**Length (metres)**
HFBR-PNS1DM	HFBR-PLS1DM	0.1
HFBR-PNS5DM	HFBR-PLS5DM	0.5
HFBR-PNS001	HFBR-PLS001	1
HFBR-PNS005	HFBR-PLS005	5
HFBR-PNS010	HFBR-PLS010	10
HFBR-PNS020	HFBR-PLS020	20
HFBR-PNS030	HFBR-PLS030	30
HFBR-PNS045	HFBR-PLS045	45
HFBR-PNS060	HFBR-PLS060	60
Simplex Improved Cable		
Standard Simplex Connectors	**Latching Simplex Connectors**	**Length (metres)**
HFBR-QNS001	HFBR-QLS001	1
HFBR-QNS005	HFBR-QLS005	5
HFBR-QNS010	HFBR-QLS010	10
HFBR-QNS020	HFBR-QLS020	20
HFBR-QNS030	HFBR-QLS030	30
HFBR-QNS045	HFBR-QLS045	45
HFBR-QNS060	HFBR-QLS060	60

Connectored Standard Plastic Fiber Optic Cable Duplex Standard Cable			
Standard Simplex Connectors	**Latching Simplex Connectors**	**Duplex Connectors**	**Length (metres)**
HFBR-PND5DM	HFBR-PLD5DM	HFBR-PMD5DM	0.5
HFBR-PND001	HFBR-PLD001	HFBR-PMD001	1.0
HFBR-PND005	HFBR-PLD005	HFBR-PMD005	5.0
HFBR-PND010	HFBR-PLD010	HFBR-PMD010	10.0
HFBR-PND020	HFBR-PLD020	HFBR-PMD020	20.0
HFBR-PND030	HFBR-PLD030	HFBR-PMD030	30.0
HFBR-PND045	HFBR-PLD045	HFBR-PMD045	45.0
HFBR-PND060	HFBR-PLD060	HFBR-PMD060	60.0

Unconnectored Cable		Length (metres)
Standard Attenuation Simplex Cable	HFBR-PUS500	500
Standard Attenuation Duplex Cable	HFBR-PUD500	500
Improved Attenuation Simplex Cable	HFBR-QUS500	500

CONNECTORS Page 16

HFBR-4501	Gray Simplex Connector/Crimp Ring
HFBR-4511	Blue Simplex Connector/Crimp Ring
HFBR-4503	Gray Simplex Latching Connector with Crimp Ring
HFBR-4513	Blue Simplex Latching Connector with Crimp Ring
HFBR-4506	Parchment Duplex Connector with Crimp Ring
HFBR-4593	Polishing Kit (Polishing Fixture, Abrasive Paper, Lapping Film)
HFBR-4505	Gray Adapter
HFBR-4515	Blue Adapter

EVALUATION KIT, HFBR-0501 **CONTENTS:**

HFBR-1524	Transmitter
HFBR-2524	Receiver
HFBR-4506	Duplex Connector with Crimp Ring
—	5 metres of Connectored Simplex Cable with Blue Simplex and Gray Simplex Latching Connectors
HFBR-4501	Gray Simplex Connector with Crimp Ring
HFBR-4513	Blue Simplex Latching Connector with Crimp Ring
HFBR-4505	Gray Adapter
—	Polishing Tool and 600 grit paper
HFBR-0501	Data Sheet and Brochure

MECHANICAL DIMENSIONS Page 20

A Note About Ordering Cable

There are four steps required to determine the proper part number for a desired cable.

Step 1 Select Standard or Improved Cable.

As explained on page 15, two levels of attenuation are available: Standard and Improved.

Step 2 Select the connector style.

Connector styles are described on page 16.

Step 3 Select Simplex or Duplex.

Step 4 Determine the cable length.

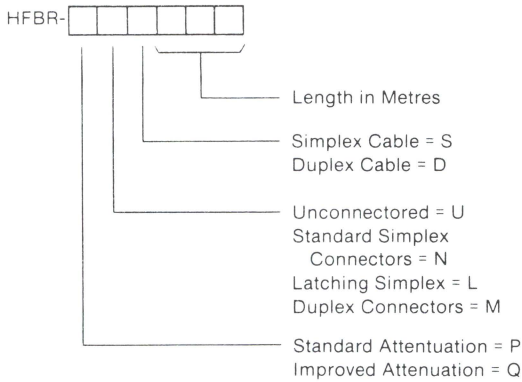
The following standard lengths are available.

Length	Last Three Digits of Part Number
0.1 m	1 DM*
0.5 m	5 DM**
1 m	001
5 m	005
10 m	010
20 m	020
30 m	030
45 m	045
60 m	060
500 m	500 (Unconnectored only)

(Custom-length cables are also available. Contact Hewlett-Packard for details.)

*Standard simplex cable only.
**Standard simplex and duplex cable only.

To determine the appropriate part number, select the letter corresponding to your selection and fill in the following:



For example:
HFBR-PUD500 is a Standard Attenuation, Unconnectored, Duplex, 500 metre cable.

A complete list of plastic cable part numbers is shown on page 23.

Please note that several cable combinations are not available. These include duplex Improved Cable, 0.1 metre and 0.5 metre simplex Improved Cable, and 0.1 metre duplex standard cables.

HEWLETT PACKARD

LOW COST, MINIATURE FIBER OPTIC COMPONENTS WITH ST* AND SMA PORTS

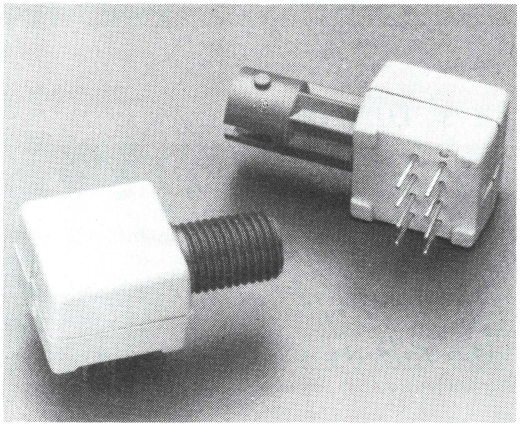
HFBR-0400 ST* and SMA SERIES

Features

- LOW COST TRANSMITTERS AND RECEIVERS
- CHOICE OF ST OR SMA PORTS
- 820 NANOMETRE WAVELENGTH TECHNOLOGY
- DATA RATES UP TO 150 MEGABAUD
- LINK DISTANCES UP TO 4 KILOMETRES
- GUARANTEED WITH 62.5/125 μm, 100/140 μm, 50/125 μm, AND 200 μm PCS FIBER SIZES
- QUICK TWIST DELIVERS LOCKING AND SPRING LOADED ST CONNECTION
- REPEATABLE ST CONNECTIONS WITHIN 0.2 dB TYPICALLY
- UNIQUE OPTICAL PORT DESIGN FOR EFFICIENT COUPLING
- AUTO-INSERTABLE AND WAVE SOLDERABLE
- NO MOUNTING HARDWARE REQUIRED
- WIDE OPERATING TEMPERATURE RANGE -40°C to 85°C
- AlGaAs EMITTERS 100% BURN-IN ENSURES HIGH RELIABILITY
- DEMONSTRATED RELIABILITY @ 40°C EXCEEDS 5 MILLION HOURS MTBF

Applications

- COMPUTER TO PERIPHERAL LINKS
- LOCAL AREA NETWORKS
- CENTRAL OFFICE SWITCH LINKS
- PBX LINKS
- COMPUTER MONITOR LINKS
- VIDEO LINKS
- MODEMS AND MULTIPLEXERS
- SUITABLE FOR TEMPEST SYSTEMS



Description

The HFBR-0400 Series of components is designed to provide cost effective, high performance fiber optic communication links for information systems and industrial applications with link distances of up to 4 kilometres. With the latest addition to the HFBR-0400 series, the 125 MHz analog receiver, data rates of up to 150 megabaud are attainable.

Transmitters and receivers are directly compatible with popular "industry-standard" connectors; ST and SMA. They are completely specified with multiple fiber sizes; including 62.5/125 μm, 100/140 μm, 50/125 μm, and 200 μm PCS.

Complete evaluation kits are available for ST and SMA product offerings; including transmitter, receiver, connectored cable, and technical literature. In addition, ST and SMA connectored cables are available.

*ST is a registered trademark of AT&T Lightguide Cable Connectors.

HFBR-0400 Series Selection Guide

Description	Part Number (ST Series)	Part Number (SMA Series)
Standard Transmitter	HFBR-1412	HFBR-1402
High Power Transmitter	HFBR-1414	HFBR-1404
5 MBd TTL Receiver	HFBR-2412	HFBR-2402
25 MHz Analog Receiver	HFBR-2414	HFBR-2404
125 MHz Analog Receiver	HFBR-2416	HFBR-2406
Evaluation Kit (5 MBd)	HFBR-0410	HFBR-0400
Connectored Cables	Various	Various

Literature Guide

Title	Description
HFBR-0400 Series Reliability Data	Transmitter & Receiver Reliability Data
Application Bulletin 73	Low-Cost Fiber Optic Transmitter & Receiver Interface Circuits
Application Bulletin 74	Digital Interface Circuits for the 125 MHz Receiver
Technical Brief 105	ST Connector/Cable Guide
Technical Brief 101	Fiber Optic SMA Connector Technology
HFBR-0400 ST and SMA Series	Transmitter & Receiver Specifications

Contact your local HP components sales office to obtain these publications.

Package Information

All HFBR-0400 Series transmitters and receivers are housed in a low-cost, dual-in-line package that is made of high strength, heat resistant, chemically resistant, and UL V-O flame retardant plastic. The transmitters are easily identified by the light grey color connector port. The receivers are easily identified by the dark grey color connector port. The package is designed for auto-insertion and wave soldering so it is ideal for high volume production applications.

Handling and Design Information

When soldering, it is advisable to leave the protective cap on the unit to keep the optics clean.

Good system performance requires clean port optics and cable ferrules to avoid obstructing the optical path. Clean compressed air often is sufficient to remove particles of dirt; methanol or Freon on a cotton swab also works well.

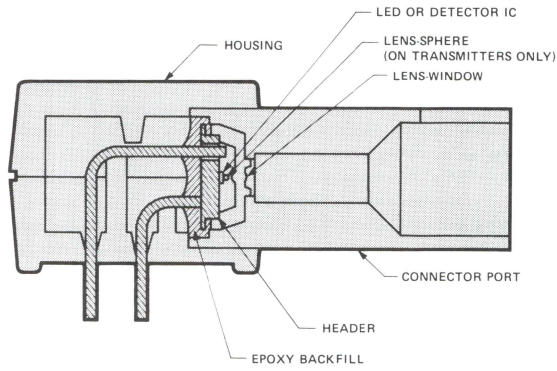


Figure 1. HFBR-0400 ST Series Cross-Sectional View

Link Design Considerations

The HFBR-14XX transmitter and the HFBR-24XX receiver can be used to design fiber optic data links that operate with 62.5/125 μm, 100/140 μm, 50/125 μm, and 200 μm PCS fiber cables.

The HFBR-14X2 standard transmitter and the HFBR-24X2 receiver are suitable for systems requiring up to 5 MBd and 2 Km. For higher data rate or longer distance, the HFBR-14X4 high power transmitter and/or the HFBR-24X4 receiver should be considered.

5 MBd LOGIC LINK DESIGN

The HFBR-14X4/24X2 Logic Link is guaranteed to work with 62.5/125 μm fiber optic cable over the entire range of 0 to 1200 metres at a data rate of dc to 5 MBd, with arbitrary data format and typically less than 25% pulse width distortion, when the transmitter is driven with I_F = 30 mA, RL = 89 Ohm as shown in Figure 2. If it is desired to economize on power or achieve lower pulse distortion, then a lower drive current (I_F) may be used. The following example will illustrate the technique for optimizing I_F.

EXAMPLE: Maximum distance required = 400 metres. From Figure 3 the drive current should be 20 mA. From the transmitter data V_F = 1.6 V (max) as shown in Figure 9.

$$R1 = \frac{V_{CC} - V_F}{I_F} = \frac{5\ V - 1.6\ V}{20\ mA} = 170\ ohm$$

The curves in Figures 3, 4, and 5 are constructed assuming no in-line splice or any additional system loss. Should the link consist of any in-line splices, these curves can still be used to calculate link limits provided they are shifted by the additional system loss in dB. For example, with 20 mA of transmitter drive current, 1.6 km link distance is achievable. With 2 dB of additional system loss, 1.2 km link distance is achievable.

LOGIC LINK DESIGN UP TO 35 MBd

For data rates up to 35 MBd, or longer distance, the HFBR-14X4 high power transmitter and/or the HFBR-24X4 receiver can be used. The table on the following page summarizes the typical performance of a 30 MBd link. For more details, please refer to HP Application Bulletin 73 (5954-8415). If circuit design assistance is needed, please contact your local Hewlett-Packard Components Field Sales Engineer.

LOGIC LINK DESIGN UP TO 150 MBd

For data rates of up to 150 MBd, the HFBR-14XX transmitters and the HFBR-24X6 receiver can be used. The table on the following page summarizes the typical performance of a 100 MBd link. For more details, please refer to HP Application Bulletin 74. If circuit design assistance is needed, please contact your local Hewlett-Packard Components Field Sales Engineer.

CABLE SELECTION

The HFBR-0400 Series can be used with fiber sizes such as 62.5/125 μm, 100/140 μm, 50/125 μm, 200 μm PCS and 1000 μm Plastic. Before selecting a fiber type, several parameters need to be carefully evaluated.

The bandwidth and attenuation (dB/km) of the selected fiber, in conjunction with the amount of optical power coupled into it will determine the achievable link length. The parameters that will significantly affect the optical power coupled into the fiber are as follows:

a. Fiber Core Diameter. As the core diameter is increased, the optical power coupled increases, leveling off at about 250 μm diameter.
b. Numerical Aperture (NA). As the NA is increased, the optical power coupled increases, leveling off at an NA of about 0.34.

In addition to the optical parameters, the environmental performance of the selected fiber/cable must be evaluated. Finally, the ease of installing connectors on the selected fiber/cable must be considered.

ST connectored fiber optic cable is available from a variety of manufacturers and distributors, including those listed in HP Technical Brief 105; ST Connector/Cable Guide. For ST Evaluation Cables from Hewlett-Packard, please refer to page 13.

ST CONNECTORS

ST connections are locking, vibration resistant, low loss and very repeatable. The HFBR-0400 ST Series Transmitters and Receivers are compatible with AT&T's ST Connector and bayonet connectors from a variety of manufacturers and distributors. For more information about ST Connectors, please refer to Technical Brief 105; ST Connector/Cable Guide.

SMA CONNECTORS

The HFBR-0400 SMA Series Transmitters and Receivers are compatible with SMA type connectors. Depending upon the type of SMA connector that is chosen, price, performance, and reliability will vary. For more information about SMA connectors, please refer to Technical Brief 101; Fiber Optic SMA Connnector Technology.

5 MBd Link Performance -40° C to +85° C unless other wise specified

Parameter	Symbol	Min.	Typ.[1]	Max.	Units	Conditions	Reference
Optical Power Budget w/62.5/125 μm Fiber	$OPB_{62.5}$	8.0	15.0		dB	HFBR-14X4/24X2 w/62.5/125 μm, NA = 0.27	
Optical Power Budget w/100/140 μm Fiber	OPB_{100}	8.5	15.0		dB	HFBR-14X2/24X2 w/100/140 μm, NA = 0.30	
Optical Power Budget w/50/125 μm Fiber	OPB_{50}	3.5	10.5		dB	HFBR-14X2/24X2 w/50/125 μm, NA = 0.18	
Optical Power Budget w/200 μm HCS Fiber	OPB_{200}	13	20.5		dB	HFBR-14X2/24X2 w/200 μm HCS, NA = 0.40	Note 2
Data Rate Synchronous		dc		5	MBaud		Note
Asynchronous		dc		2.5	MBaud		Note 2, Fig. 7
Propagation Delay LOW to HIGH	t_{PLH}		72		nsec	T_A = 25° C, P_R = -21 dBm Peak	Fig. 6, 7, 8
Propagation Delay HIGH to LOW	t_{PHL}		46		nsec		
System Pulse Width Distortion	t_{PLH}-t_{PHL}		25		nsec	ℓ = 1.0 metre	
Bit Error Rate	BER			10^{-9}		Data Rate ≤ 5 MBaud P_R > -24 dBm Peak	

Notes:
1. Typical data at T = 25° C, V_{CC} = 5.0 V dc, P_R = -27.0 dBm.
2. Synchronous data rate limit is based on these assumptions: a) 50% duty factor modulation, e.g., Manchester I or BiPhase Manchester II; b) continuous data; c) PLL Phase Lock Loop demodulation; d) TTL threshold.

Asynchronous data rate limit is based on these assumptions: a) NRZ data; b) arbitrary timing — no duty factor restriction; c) TTL threshold.
The EYE pattern describes the timing range within which there is no uncertainty of the logic state, relative to a specific threshold, due to either noise or intersymbol prop. delay effects.

30 MBd Link Performance (see Application Bulletin 73 for details)

Parameter	Symbol	Min.	Typ.[1]	Max.	Units	Conditions
Optical Power Budget w/62.5/125 μm Fiber	$OPB_{62.5}$		13.5		dB	HFBR-14X4/24X4 w/62.5/125 μm, NA = 0.27
Optical Power Budget w/100/140 μm Fiber	OPB_{100}		13.5		dB	HFBR-14X2/24X4 w/100/140 μm, NA = 0.30
Optical Power Budget w/50/125 μm Fiber	OPB_{50}		9		dB	HFBR-14X2/24X4 w/50/125 μm, NA = 0.18
Optical Power Budget w/200 μm PCS Fiber	OPB_{200}		19		dB	HFBR-14X4/24X4 w/200 μm PCS, NA = 0.40
Data Format NRZ		dc	30		MBaud	Reference AB 73 for circuits details, Note 2, 3
Propagation Delay LOW to HIGH	t_{PLH}		12		nsec	T_A = 25° C, P_R = -13 dBm Peak
Propagation Delay HIGH to LOW	t_{PHL}		8		nsec	
System Pulse Width Distortion	t_{PLH}-t_{PHL}		4		nsec	ℓ = 1.0 metre
Bit Error Rate	BER			10^{-9}		Data Rate ≤ 30 MBaud P_R > -25.5 dBm Peak

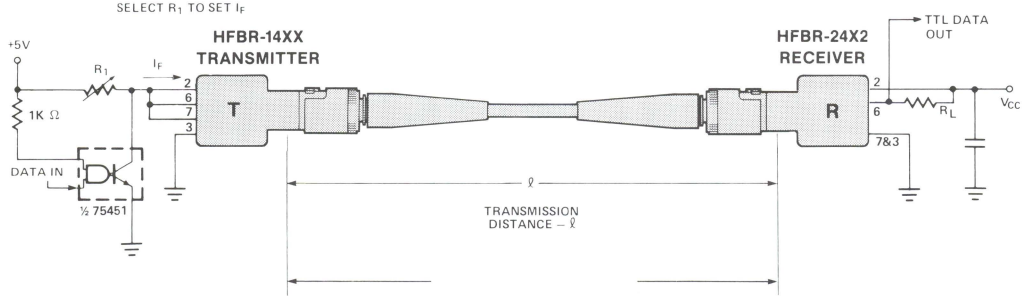
Notes:
1. Typical data at T = 25° C, V_{CC} = 5.0 V dc.
2. This circuit utilizes the LT1016 comparator from Linear Technology Corporation. If operated at 5 MBd, an additional 4.5 dB of optical power budget can be obtained.
3. If HFBR-24X4 is replaced with the HFBR-24X6, an additional 5.5 dB of optical power budget can be obtained at 30 MHd NRZ.

100 MBd Link Performance (see Application Bulletin 74 for details)

Parameter	Symbol	Min.	Typ.[1]	Max.	Units	Conditions
Optical Power Budget w/62.5/125 μm Fiber	$OPB_{62.5}$		19		dB	HFBR-14X4/24X6 w/62.5/125 μm, NA = 0.27
Optical Power Budget w/100/140 μm Fiber	OPB_{100}		19		dB	HFBR-14X2/24X6 w/100/140 μm, NA = 0.30
Optical Power Budget w/50/125 μm Fiber	OPB_{50}		14		dB	HFBR-14X4/24X6 w/50/125 μm, NA = 0.18
Optical Power Budget w/200 μm PCS Fiber	OPB_{200}		24		dB	HFBR-14X2/24X6 w/200 μm PCS, NA = 0.40
Data Format 20% to 80% Duty Factor			100		MBaud	Reference AB 74 for circuit details, Note 2
Propagation Delay LOW to HIGH	t_{PLH}		5		nsec	T_A = 25° C, P_R = -7 dBm Peak
Propagation Delay HIGH to LOW	t_{PHL}		4		nsec	
System Pulse Width Distortion	t_{PLH}-t_{PHL}		1		nsec	ℓ = 1.0 metre
Bit Error Rate	BER			10^{-9}		Data Rate ≤ 100 MBaud P_R > -31 dBm Peak

Notes:
1. Typical data at T_A = 25° C, V_{EE} = -5.2 Vdc, V_{CC} = 0 (ECL).
2. The optical power budgets at 100 MBd were measured with an unrestricted receiver, without a Nyquist filter. A 10116 ECL line receiver was used in the receiver digitizing circuit. If unnecessary bandwidth is eliminated by low-pass filtering, an additional 2 dB of link budget is attainable at 30 MBd.

5 MBd Link Performance



NOTE:
IT IS ESSENTIAL THAT A BYPASS CAPACITOR (0.01 μF TO 0.1 μF CERAMIC) BE CONNECTED FROM PIN 2 TO PIN 7 OF THE RECEIVER. TOTAL LEAD LENGTH BETWEEN BOTH ENDS OF THE CAPACITOR AND THE PINS SHOULD NOT EXCEED 20 mm.

Figure 2. Typical Circuit Configuration

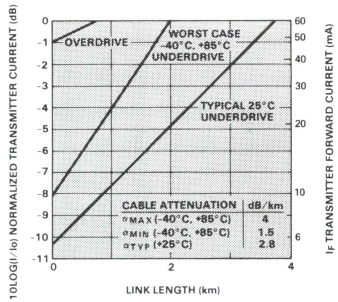


Figure 3. HFBR-1414/HFBR-2412 Link Design Limits with 62.5/125 μm Cable

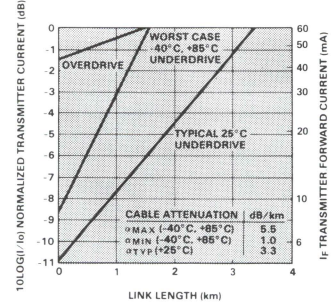


Figure 4. HFBR-14X2/HFBR-24X2 Link Design Limits with 100/140 μm Cable

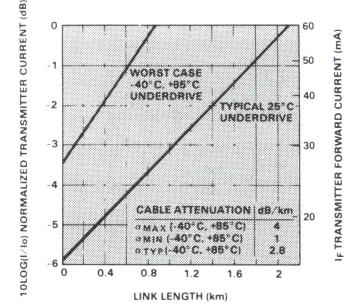


Figure 5. HFBR-14X4/HFBR-24X2 Link Design Limits with 50/125 μm Cable

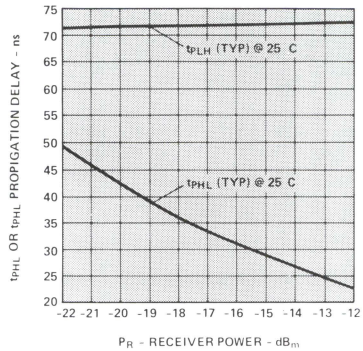


Figure 6. Propagation Delay through System with One Metre of Cable

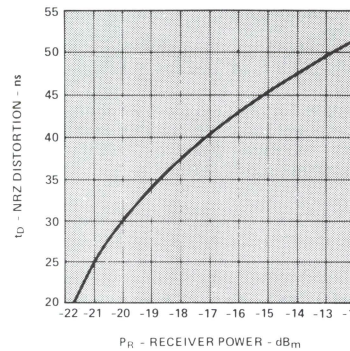


Figure 7. Typical Distortion of NRZ EYE-pattern with Pseudo Random Data at 5 Mb/s (see note 2)

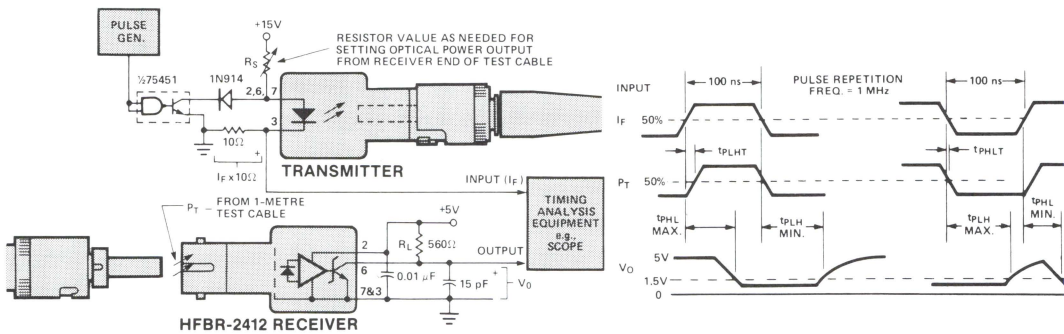


Figure 8. System Propagation Delay Test Circuit and Waveform Timing Definitions

HIGH SPEED LOW COST FIBER OPTIC TRANSMITTER

HFBR-1412 (ST)
HFBR-1414 (ST)
HFBR-1402 (SMA)
HFBR-1404 (SMA)

Description

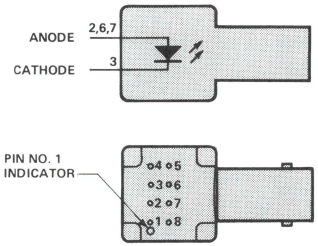
The HFBR-14XX fiber optic transmitter contains an 820 nm GaAlAs emitter capable of efficiently launching optical power into four different optical fiber sizes: 62.5/125 μm, 100/140 μm, 50/125 μm, and 200 μm PCS. This allows the designer flexibility in choosing the fiber size. The HFBR-14XX is designed to operate with the Hewlett-Packard HFBR-24XX fiber optic receivers.

The HFBR-14XX transmitter's high coupling efficiency allows the emitter to be driven at low current levels resulting in low power consumption and increased reliability of the transmitter. The HFBR-14X4 high power transmitter is optimized for small size fiber and typically can launch -16.5 dBm optical power into 50/125 μm fiber and -12 dBm into 62.5/125 μm fiber. The HFBR-14X2 standard transmitter typically can couple -11.5 dBm of optical power into 100/140 μm fiber cable. It is ideal for large size fiber such as 100/140 μm. The high power level is useful for systems where star couplers, taps, or inline connectors create large fixed losses.

Consistent coupling efficiency is assured by the double-lens optical system (Figure 1). Power coupled into any of the three fiber types varies less than 5 dB from part to part at a given drive current and temperature. The benefit of this is reduced dynamic range requirements on the receiver.

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Unit	Notes
Storage Temperature		T_S	-55	+85	°C	
Operating Temperature		T_A	-40	+85	°C	
Lead Soldering Cycle	Temp.			+260	°C	
	Time			10	sec	
Forward Input Current	Peak	I_{FPK}		120	mA	Note 1
	DC	I_{FDC}		60	mA	
Reverse Input Voltage		V_{BR}		1.8	V	



BOTTOM VIEW

PIN	FUNCTION
1	N.C.
2*	ANODE
3	CATHODE
4	N.C.
5	N.C.
6*	ANODE
7*	ANODE
8	N.C.

*PINS 2, 6 AND 7 ELECTRICALLY CONNECTED TO HEADER

CAUTION: The small junction sizes inherent to the design of this component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

Electrical/Optical Characteristics -40° C to +85° C unless otherwise specified

Parameter	Symbol	Min.	Typ.[2]	Max.	Units	Conditions	Notes
Forward Voltage	V_F	1.58	1.80	2.19	V	I_F = 60 mA	Fig. 9
Forward Voltage Temperature Coefficient	V_F/T		-0.86		mV/° C	I_F = 60 mA	Fig. 9
Reverse Input Voltage	V_{BR}	1.8	3.8		V	I_R = 100 μA	
Peak Emission Wavelength	λ_P		820		nm		Fig. 12
Diode Capacitance	C_T		145		pF	V = 0, f = 1 MHz	
Optical Power Temperature Coefficient	$\Delta P_T/\Delta T$		-0.016		dB/° C	I_F = 60 mA	
Thermal Resistance	Θ_{JA}		240		°C/W		Note 3, 8
Numerical Aperture (HFBR-14X2)	NA_{14X2}		0.49				
Numerical Aperture (HFBR-14X4)	NA_{14X4}		0.31				
Optical Port Diameter (HFBR-14X2)	$D_{T_{14X2}}$		290		μm		Note 4
Optical Port Diameter (HFBR-14X4)	$D_{T_{14X4}}$		150		μm		Note 4

Electrical/Optical Characteristics -40° C to +85° C unless otherwise specified

HFBR-1412 and HFBR-1402 Peak Output Optical Power Measured Out of 1m of Cable

Parameter	Symbol	Min.	Typ.[2]	Max.	Units	Conditions		Notes
62.5/125 μm Fiber Cable NA = 0.27	$P_{T_{62}}$	-19.0	-16.0	-14.0	dBm	T_A = 25° C	I_F = 60 mA	Notes 5,6,9,10
		-20.0		-13.0	dBm	T_A = -40° C to +85° C		
100/140 μm Fiber Cable NA = 0.30	$P_{T_{100}}$	-15.0	-12.0	-10.0	dBm	T_A = 25° C		
		-16.0		-9.0	dBm	T_A = -40° C to +85° C		
50/125 μm Fiber Cable NA = 0.18	$P_{T_{50}}$	-22.5	-19.5	-17.5	dBm	T_A = 25° C		
		-23.5		-16.5	dBm	T_A = -40° C to +85° C		
200 μm PCS Fiber Cable NA = 0.40	$P_{T_{200}}$	-10.0	-6.5	-4.0	dBm	T_A = 25° C		
		-11.0		-3.0	dBm	T_A = -40° C to +85° C		

HFBR-1414 and HFBR-1404 Peak Output Optical Power Measured Out of 1m of Cable

62.5/125 μm Fiber Cable NA = 0.27	$P_{T_{62}}$	-15.0	-12.0	-10.0	dBm	T_A = 25° C	I_F = 60 mA	Notes 5,6,9,10
		-16.0		-9.0	dBm	T_A = -40° C to +85° C		
100/140 μm Fiber Cable NA = 0.30	$P_{T_{100}}$	-9.5	-6.5	-4.5	dBm	T_A = 25° C		
		-10.5		-3.5	dBm	T_A = -40° C to +85° C		
50/125 μm Fiber Cable NA = 0.18	$P_{T_{50}}$	-19.5	-16.5	-14.5	dBm	T_A = 25° C		
		-20.5		-13.5	dBm	T_A = -40° C to +85° C		
200 μm PCS Fiber Cable NA = 0.40	$P_{T_{200}}$	-4.5	-3.0	-1.5	dBm	T_A = 25° C		
		-5.5		-2.5	dBm	T_A = -40° C to +85° C		

WARNING: OBSERVING THE TRANSMITTER OUTPUT POWER UNDER MAGNIFICATION MAY CAUSE INJURY TO THE EYE. When viewed with the unaided eye, the infrared output is radiologically safe. However, when viewed under magnification, precaution should be taken to avoid exceeding the limits recommended in ANSI Z136.1-1981.

Dynamic Characteristics

Parameter	Symbol	Min.	Typ.[2]	Max.	Units	Conditions	Notes
Rise Time, Fall Time (10 to 90%)	t_r, t_f		4.0	6.5	nsec	I_F = 60 mA No pre-bias	Note 7, 11 Fig. 6
Propagation Delay LOW to HIGH	t_{PLH}		10		nsec	I_{FPK} = 60 mA	
Propagation Delay HIGH to LOW	t_{PHL}		8		nsec	I_{FPK} = 60 mA	

Notes:

1. For I_{FPK} = 120 mA, the time duration should not exceed 2 ns.
2. Typical data at T_A = 25° C.
3. Thermal resistance is measured with the transmitter coupled to a connector assembly and mounted on a printed circuit board.
4. D_T is measured at the plane of the fiber face and defines a diameter where the optical power density is within 10 dB of the maximum.
5. P_T is measured with a large area detector at the end of 1 metre of mode stripped cable, with an AT&T ST precision ceramic ferrule for HFBR-1412/1414, and with a OFTI NOFC precision ceramic ferrule for HFBR-1402/1404. This approximates a standard test connector.
6. When changing μW to dBm, the optical power is referenced to 1 mW (1000 μW). Optical Power P (dBm) = 10 log P (μW)/1000 μW.
7. Pre-bias is recommended if I_F < 30 mA, see recommended drive circuit in Figure 11.
8. Pins 2, 6 and 7 are welded to the anode header connection to minimize the thermal resistance from junction to ambient. To further reduce the thermal resistance, the anode trace should be made as large as is consistent with good RF circuit design.
9. Fiber NA is measured at the end of 2 metres of mode stripped fiber, using the far-field pattern. NA is defined as the sine of the half angle, determined at 5% of the peak intensity point.
10. $P_{T_{100}}$ specifications are for HP's 100/140 μm fiber cable (NA = 0.30 @ 10% at peak intensity). When using other manufacturer's fiber cable, results will vary due to differing NA values and specification methods.
11. For data rates of 100 megabaud or higher, maximum rise and fall times of less than 4 nanoseconds are desirable. Please see your local Hewlett-Packard Field Sales Engineer for higher speed versions of HFBR-14XX.

Recommended Drive Circuits

For data rates of 35 MBd or less, the transmitter drive circuit in Figure 2 will be adequate. For greater than 35 MBd operation, shorter rise and fall times are desirable. Rise and fall times can be improved by using a pre-bias current and "speed-up" capacitor. A pre-bias current will significantly reduce the junction capacitance and will not change the extinction ratio appreciably. The recommended TTL comptible drive circuit in Figure 11 using a speed-up capacitor will provide a typical rise and fall times of 4 ns. The following set of equations will give the component values for the circuit for different transmitter drive current:

$$R_y = \frac{(V_{CC} - V_F) + 3.2\,(V_{CC} - V_F - 1.4V)}{I_{FON}}$$

$$R_x = \left(\frac{R_y}{3.2} - 10\ \Omega\right)$$

$$R_{x_1} = \frac{R_x + 10\Omega}{2}$$

$$R_{x_2} = R_{x_1} - 10\Omega$$

$$C = \frac{2.0\ \text{nsec}}{R_{x_1}}$$

Example: For $I_{F_{ON}} = 27$ mA, V_F can be obtained from Fig. 9 (= 1.7 V)

$$R_y = \frac{(5V - 1.7V) + 3.2\,(5\ V - 1.7\ V - 1.4\ V)}{27\ \text{mA}}$$

$$= \frac{3.3\ V + 6.1\ V}{27\ \text{mA}} = 348\ \Omega$$

$$R_x = \left(\frac{348\ \Omega}{3.2}\right) - 10\ \Omega = 98.8\ \Omega$$

$$R_{x_1} = \frac{98.8\ \Omega + 10\ \Omega}{2} = 54.4\ \Omega$$

$$R_{x_2} = 54.4 - 10 = 44.4\ \Omega$$

$$C = \frac{2\ \text{nsec}}{R_{x_1}} = 36.8\ \text{pF}$$

Selected the following standard value components:

$R_y = 330\ \Omega$ $R_{x_1} = 56\ \Omega$ $R_{x_2} = 47\ \Omega$ $C = 39$ pF

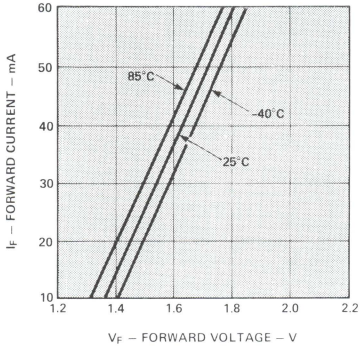


Figure 9. Forward Voltage and Current Characteristics

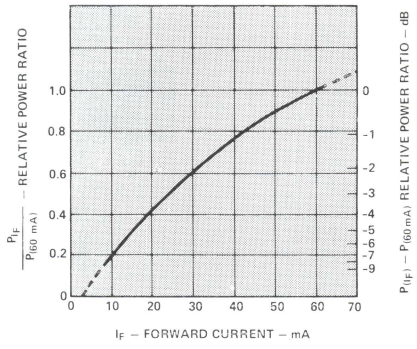


Figure 10. Normalized Transmitter Output vs. Forward Current

FIBER OPTICS

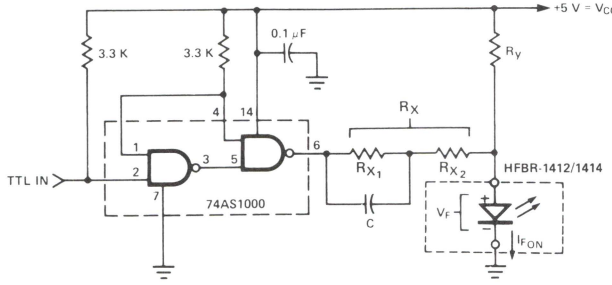


Figure 11. Recommended Drive Circuit

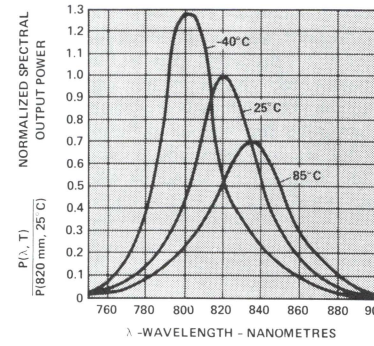


Figure 12. Transmitter Spectrum Normalized to the Peak at 25°C

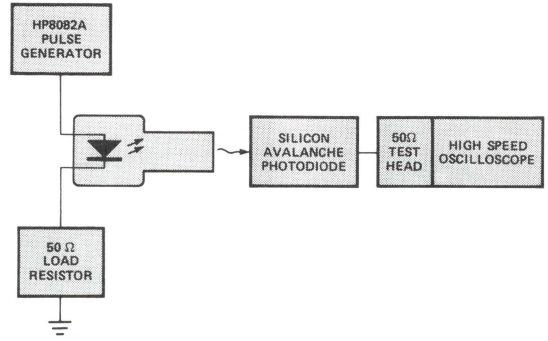


Figure 13. Test Circuit for Measuring t_r, t_f

5 MBd LOW COST FIBER OPTIC RECEIVER

HFBR-2412 (ST)
HFBR-2402 (SMA)

Description

The HFBR-24X2 fiber optic receiver is designed to operate with the Hewlett-Packard HFBR-14XX fiber optic transmitter and 62.5/125 μm, 100/140 μm, and 50/125 μm fiber optic cable. Consistent coupling into the receiver is assured by the lensed optical system (Figure 1). Response does not vary with fiber size.

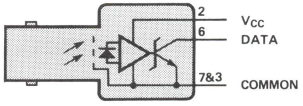
The HFBR-24X2 receiver incorporates an integrated photo IC containing a photodetector and dc amplifier driving an open-collector Schottky output transistor. The HFBR-24X2 is designed for direct interfacing to popular logic families. The absence of an internal pull-up resistor allows the open-collector output to be used with logic families such as CMOS requiring voltage excursions much higher than V_{CC}.

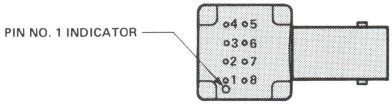
Both the open-collector "Data" output Pin 6 and V_{CC} Pin 2 are referenced to "Com" Pin 3, 7. The "Data" output allows busing, strobing and wired "OR" circuit configurations. The transmitter is designed to operate from a single +5 V supply. It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from Pin 2 (V_{CC}) to Pin 3 (circuit common) of the receiver.

CAUTION: The small junction sizes inherent to the design of this component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Reference
Storage Temperature		T_S	-55	+85	°C	
Operating Temperature		T_A	-40	+85	°C	
Lead Soldering Cycle	Temp.			+260	°C	Note 1
	Time			10	sec	
Supply Voltage		V_{CC}	-0.5	7.0	V	
Output Current		I_O		25	mA	
Output Voltage		V_O	-0.5	18.0	V	
Output Collector Power Dissipation		$P_{O\ AV}$		40	mW	
Fan Out (TTL)		N		5		Note 2





BOTTOM VIEW

PIN	FUNCTION
1	N.C.
2	V_{CC} (5 V)
3*	COMMON
4	N.C.
5	N.C.
6	DATA
7*	COMMON
8	N.C.

*PINS 3 AND 7 ARE ELECTRICALLY CONNECTED TO HEADER

(Continued on next page)

Electrical/Optical Characteristics -40° C to +85° C unless otherwise specified

Fiber sizes with core diameter ≤ 100 μm and NA ≤ 0.4, 4.75 ≤ V_{CC} ≤ 5.25 V

Parameter	Symbol	Min.	Typ.[3]	Max.	Units	Conditions	Reference
High Level Output Current	I_{OH}		5	250	μA	V_O = 18V P_R < -40 dBm	
Low Level Output Voltage	V_{OL}		0.4	0.5	V	I_O = 8 mA P_R > -24 dBm	
High Level Supply Current	I_{CCH}		3.5	6.3	mA	V_{CC} = 5.25 V P_R < -40 dBm	
Low Level Supply Current	I_{CCL}		6.2	10	mA	V_{CC} = 5.25 V P_R > -24 dBm	
Equivalent N.A.	NA		.50				
Optical Port Diameter	D_R		400		μm		Note 4

Dynamic Characteristics -40° C to +85° C unless otherwise specified; 4.75 ≤ V_{CC} ≤ 5.25 V

Parameter	Symbol	Min.	Typ.[3]	Max.	Units	Conditions	Notes
Peak Input Power Level Logic HIGH	P_{RH}			-40 0.1	dBm μW	λ_P = 820 nm	Note 5
Peak Input Power Level Logic LOW	P_{RL}	-25.4 2.9		-9.2 120	dBm μW	T_A= +25° C, I_{OL} = 8 mA	Note 5
		-24.0 4.0		-10.0 100	dBm μW	-40 < T_A < 85° C, I_{OL} = 8 mA	
Propagation Delay LOW to HIGH	t_{PLHR}		65		nsec	T_A = 25° C, P_R = -21 dBm Data Rate = 5 MBd BER = 10^{-9}	Note 6
Propagation Delay HIGH to LOW	t_{PHLR}		49		nsec		

Notes:

1. 2.0 mm from where leads enter case.
2. 8 mA load (5 x 1.6 mA), R_L = 560 Ω.
3. Typical data at T_A = 25° C, V_{CC} = 5.0 V dc.
4. D_R is the effective diameter of the detector image on the plane of the fiber face. The numerical value is the product of the actual detector diameter and the lens magnification.
5. Measured at the end of 100/140 μm fiber optic cable with large area detector.
6. Propagation delay through the system is the result of several sequentially-occurring phenomena. Consequently it is a combination of data-rate-limiting effects and of transmission-time effects. Because of this, the data-rate limit of the system must be described in terms of time differentials between delays imposed on falling and rising edges.
   As the cable length is increased, the propagation delays increase at 5 ns per metre of length. Data rate, as limited by pulse width distortion, is not affected by increasing cable length if the optical power level at the receiver is maintained.

25 MHz LOW COST FIBER OPTIC RECEIVER

HFBR-2414 (ST)
HFBR-2404 (SMA)

Description

The HFBR-24X4 fiber optic receiver is designed to operate with the Hewlett-Packard HFBR-14XX fiber optic transmitters and 62.4/125 μm, 100/140 μm, and 50/125 μm, fiber optic cable. Consistent coupling into the receiver is assured by the lensed optical system (Figure 1). Response does not vary with fiber size.

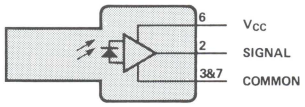
The receiver output is an analog signal that can be optimized for a variety of distance/data rate requirements. Low-cost external components can be used to convert the analog output to logic compatible signal levels for various data formats and data rates up to 35 MBaud. This distance/data rate tradeoff results in increased optical power budget at lower data rates which can be used for additional distance or splices.

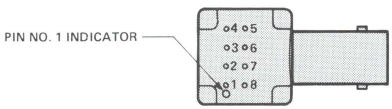
The HFBR-24X4 receiver contains a PIN photodiode and low noise transimpedance pre-amplifier integrated circuit with an inverting output (see note 3). The HFBR-24X4 receives an optical signal and converts it to an analog voltage. The output is a buffered emitter-follower. Because the signal amplitude from the HFBR-24X4 receiver is much larger than from a simple PIN photodiode, it is less susceptible to EMI, especially at high signal rates. The receiver has a minimum dynamic range of 15 dB over temperature (assuming a 10^{-9} BER).

The frequency response is typically dc to 25 MHz. Although the HFBR-24X4 is an analog receiver, it is easily made compatible with digital systems. Please refer to Application Bulletin 73 for simple and inexpensive circuits that operate up to 35 MBd.

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Unit	Reference
Storage Temperature		T_S	-55	+85	°C	
Operating Temperature		T_A	-40	+85	°C	
Lead Soldering Cycle	Temp.			+260	°C	Note 1
	Time			10	sec	
Signal Pin Voltage		V_{SIGNAL}	-0.5	1	V	
Supply Voltage		V_{CC}	-0.5	7.0	V	





BOTTOM VIEW

PIN	FUNCTION
1	N.C.
2	SIGNAL
3*	COMMON
4	N.C.
5	N.C.
6	V_{CC} (5 V)
7*	COMMON
8	N.C.

*PINS 3 AND 7 ARE ELECTRICALLY CONNECTED TO HEADER

CAUTION: The small junction sizes inherent to the design of this component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

(Continued on next page)

Electrical/Optical Characteristics -40° C to +85° C; $4.75 \leq V_{CC} \leq 5.25$; $R_{LOAD} = 511\Omega$

Fiber sizes with core dia. ≤ 100 microns, and N.A. ≤ 0.4 unless otherwise specified.

Parameter	Symbol	Min.	Typ[5]	Max.	Unit	Conditions	Reference
Responsivity	R_P	5.1	7	10.9	mV/μW	$T_A = 25°C$ at 820 nm	
		4.6		12.3	mV/μW		
RMS Output Noise Voltage	V_{NO}		.30	.36	mV	$T_A = 25°C$, $P_R = 0\mu W$	
				.43	mV	$P_R = 0\mu W$	
Equivalent Optical Noise Input Power	P_N		-43.7	-40.3	dBm		
			.042	.094	μW		
Peak Input Power	P_R			-12.6	dBm	$T_A = 25°C$	Note 2
				55	μW		
				-14	dBm		
				40	μW		
Output Impedance	Z_O		20		Ω	Test Frequency = 20 MHz	
DC Output Voltage	V_{odc}		.7		V	$P_R = 0\mu W$	Note 3
Power Supply Current	I_{CC}		3.4	6.0	mA	$R_{LOAD} = \infty$	
Equivalent N.A.	NA		.35				
Equivalent Diameter	D_R		250		μm		Note 4

Dynamic Characteristics

-40° C to +85° C; $4.75 \leq V_{CC} \leq 5.25$; $R_{LOAD} = 511\Omega$, $C_{LOAD} = 13$ pF unless otherwise specified

Parameter	Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Reference
Rise/Fall Time, 10% to 90%	t_r, t_f		14	19.5	ns	$T_A = 25°C$ $P_R = 10\ \mu W$ Peak	Note 6
				26	ns		
Pulse Width Distortion	$t_{phl} - t_{plh}$			2	ns	$P_R = 40\ \mu W$ Peak	
Overshoot			4		%	$T_A = 25°C$	Note 7
Bandwidth (Electrical)	BW_e		25		MHz		
Power Supply Rejection Ratio (Referred to Output)	PSRR		50		dB	at 2 MHz	Note 8

Notes:

1. 2.0 mm from where leads enter case.
2. If $P_R > 40\mu W$, then pulse width distortion may increase. At Pin = 80μW and $T_A = 85°C$, some units have exhibited as much as 100 ns pulse width distortion.
3. $V_{OUT} = V_{ODC} + (R_P \times P_R)$.
4. D_R is the effective diameter of the detector image on the plane of the fiber face. The numerical value is the product of the actual detector diameter and the lens magnification.
5. Typical specifications are for operation at $T_A = 25°C$ and $V_{CC} = 5.0V$.
6. Input optical signal is assumed to have 10% - 90% rise and fall times of less than 6 ns.
7. Percent overshoot is defined as: $\frac{V_{PK} - V_{100\%}}{V_{100\%}} \times 100\%$
8. Output referred PSRR is defined as $20 \log \left(\frac{V_{POWER\ SUPPLY\ RIPPLE}}{V_{OUT\ RIPPLE}} \right)$

125 MHz LOW COST FIBER OPTIC RECEIVER

HFBR-2416 (ST)
HFBR-2406 (SMA)

Description

The HFBR-24X6 fiber optic receiver is designed to operate with the Hewlett-Packard HFBR-14XX fiber optic transmitters and 62.5/125 μm, 100/140 μm, and 50/125 μm fiber optic cable. Consistent coupling into the receiver is assured by the lensed optical system (Figure 1). Response does not vary with fiber size for core diameters of 100 μm or less.

The receiver output is an analog signal which allows follow-on circuitry to be optimized for a variety of distance/data rate requirements. Low-cost external components can be used to convert the analog output to logic compatible signal levels for various data formats and data rates up to 150 MBaud. This distance/data rate tradeoff results in increased optical power budget at lower data rates which can be used for additional distance or splices.

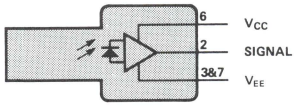
The HFBR-24X6 receiver contains a PIN photodiode and low noise transimpedance pre-amplifier integrated circuit. The HFBR-24X6 receives an optical signal and converts it to an analog voltage. The output is a buffered emitter-follower. Because the signal amplitude from the HFBR-24X6 receiver is much larger than from a simple PIN photodiode, it is less susceptible to EMI, especially at high signal rates. The receiver has a minimum dynamic range of 23 dB over temperature (assuming 10^{-9} BER). Because the maximum receiver input power is 6 dB larger and the noise is 2 dB lower over temperature than HP's HFBR-24X4 25 MHz receiver, the HFBR-24X6 is well suited for more demanding link designs that require wide receiver dynamic range.

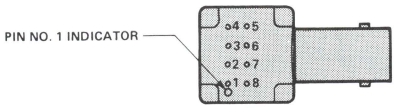
The frequency response is typically dc to 125 MHz. For bandwidth selection contact your HP Components sales engineer. Although the HFBR-24X6 is an analog receiver, it is easily made compatible with digital systems. Please refer to Application Bulletin 74 for simple and inexpensive circuits that operate up to 150 MBaud.

The recommended AC coupled receiver circuit is shown in Figure 14. It is essential that a 10 ohm resistor be connected between V_{EE} and the power supply, and a 0.1 μF ceramic bypass capacitor be connected between the power supply and ground.

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Unit	Reference
Storage Temperature		T_S	-55	+85	°C	
Operating Temperature		T_A	-40	+85	°C	
Lead Soldering Cycle	Temp			+260	°C	Note 1
	Time			10	sec	
Signal Pin Voltage		V_{SIGNAL}	-0.5	V_{CC}	V	
Supply Voltage		V_{CC}-V_{EE}	-0.5	6.0	V	
Output Current		I_O		25	mA	





BOTTOM VIEW

PIN	FUNCTION
1	N.C.
2	SIGNAL
3*	V_{EE}
4	N.C.
5	N.C.
6	V_{CC}
7*	V_{EE}
8	N.C.

*PINS 3 AND 7 ARE ELECTRICALLY CONNECTED TO HEADER

CAUTION: The small junction sizes inherent to the design of this component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

(Continued on next page)

Electrical/Optical Characteristics

-40° C to +85° C; -5.45 ≤ Supply Voltage ≤, - 4.75, R_{LOAD} = 511 Ω, Fiber sizes with core dia. ≤ 100 microns, and N.A. ≤ 0.35 unless otherwise specified.

Parameter	Symbol	Min.	Typ.[2]	Max.	Unit	Conditions	Reference
Responsivity	R_P	5	7	9	mV/μW	T_A = 25° C at 820 nm, 50 MHz	Note 3, 4
		4.5		11.5	mV/μW	@ 820 nm, 50 MHz	
RMS Output Noise Voltage	V_{NO}		0.38	0.53	mV	Bandwidth Filtered @ 75 MHz P_R = 0μW	Note 5
				0.70	mV	Unfiltered Bandwidth P_R = 0μW	Figure 15
Equivalent Optical Noise Input Power (RMS)	P_N		-43.0	-41.9	dBm	Bandwidth Filtered @ 75 MHz	
			0.050	0.065	μW		
Peak Input Power	P_R			-7.6	dBm	T_A = 25° C	Figure 16 Note 6
				175	μW		
				-8.2	dBm		
				150	μW		
Output Impedance	Z_O		30		Ω	Test Frequency = 50 MHz	
DC Output Voltage	V_{odc}	-4.2	-3.1	-2.4	V	P_R = 0μW	
Power Supply Current	I_{EE}		9	15	mA	R_{LOAD} = ∞	
Equivalent N.A.	NA		0.35				
Equivalent Diameter	D_R		324		μm		Note 7

Dynamic Characteristics

-40° C to +85° C; -5.45 ≤ Supply Voltage ≤, - 4.75, R_{LOAD} = 511 Ω, C_{LOAD} = 5 pF unless otherwise specified

Parameter	Symbol	Min.	Typ.[2]	Max.	Unit	Conditions	Reference
Rise/Fall Time 10% to 90%	t_r, t_f		3.3	6.3	ns	P_R = 100 μW	Figure 17
Pulse Width Distortion	PWD		0.4	2.5	ns	P_R = 150 μW Peak	Note 8, Figure 17
Overshoot			2		%	P_R = 5 μW Peak, $t_{r_{opt}}$ = 1.5 ns	Note 9
Bandwidth (Electrical)	BW_e		125		MHz	-3 dB electrical	Note 10
Power Supply Rejection Ratio	PSRR		20		dB	at 10 MHz	Note 11
Bandwidth · Rise Time Product			0.41		Hz · s		Note 12

Notes:

1. 2.0 mm from where leads enter case.
2. Typical specifications are for operation at T_A = 25° C and V_{EE} = -5.2 Vdc.
3. For 200 μm PCS fibers, typical responsivity will be 6 mV/μW. Other parameters will change as well.
4. Pin #2 should be ac coupled to a 511 ohm load. Load capacitance must be less than 5 pf.
5. Measured with a 3 pole Bessel filter with a 75 MHz, -3 dB bandwidth. Recommended receiver filters for various bandwidths are provided in Application Bulletin 74.
6. Overdrive is defined at PWD = 2.5 ns.
7. D_R is the effective diameter of the detector image on the plane of the fiber face. The numerical value is the product of the actual detector diameter and the lens magnification.
8. Measured with a 10 ns pulse width, 50% duty cycle, at the 50% amplitude point of the waveform.
9. Percent overshoot is defined as: $\frac{V_{PK} - V_{100\%}}{V_{100\%}} \times 100\%$.
10. For bandwidth selection contact your HP Componenets sales engineer.
11. Output referred P.S.R.R. is defined as $20 \log \left(\frac{V_{POWER\ SUPPLY\ RIPPLE}}{V_{OUT\ RIPPLE}} \right)$
12. The conversion factor for the rise time to bandwidth is 0.41 since the HFBR-24X6 has a second order bandwidth limiting characteristic.

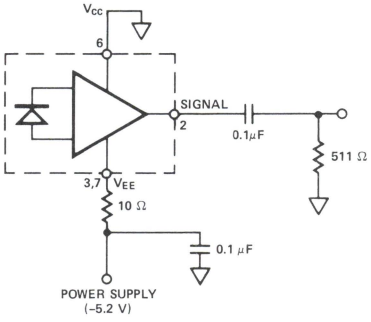


Figure 14. Recommended AC Coupled Receiver Circuit

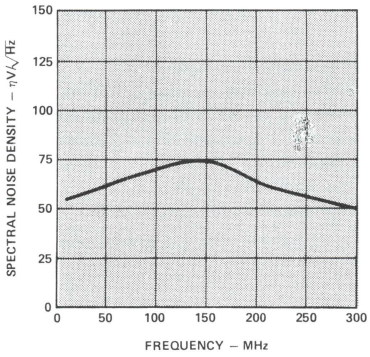


Figure 15. Typical Spectral Noise Density vs. Frequency

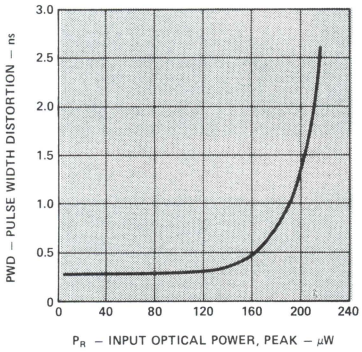


Figure 16. Typical Pulse Width Distortion vs. Peak Input Power

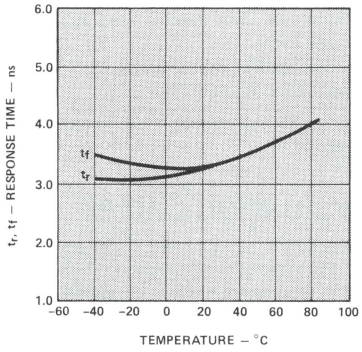


Figure 17. Typical Rise and Fall Times vs. Temperature

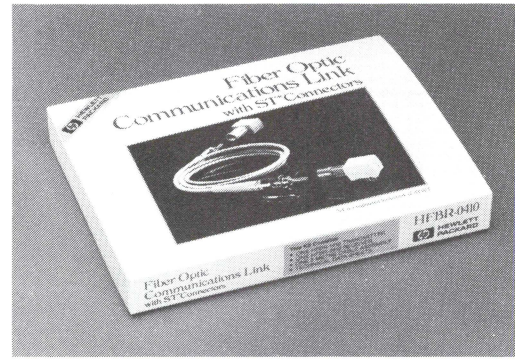
ST Evaluation Kit

The HFBR-0410 kit is a simple and inexpensive way to demonstrate the performance of Hewlett-Packard's HFBR-0400 ST Series transmitters and receivers.

The HFBR-0410 ST Evaluation Kit contains the following items:

- One HFBR-1412 transmitter
- One HFBR-2412 five megabaud TTL receiver
- Three metres of ST Connectored 62.5/125 μm fiber optic cable with low cost plastic ferrules
- HFBR-0400 Series data sheets
- HP Application Bulletin 73
- ST connector and cable data sheets

To order an ST Evaluation Kit, please specify HFBR-0410, Quantity 1.



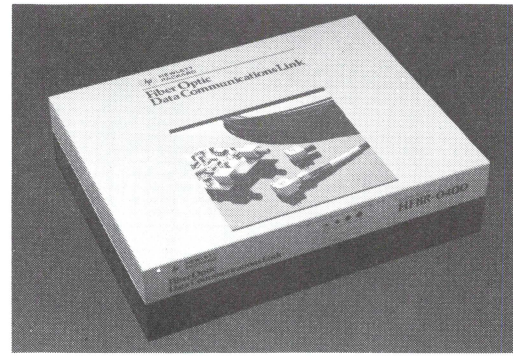
SMA Evaluation Kit

The HFBR-0400 kit is a simple and inexpensive way to demonstrate the performance of Hewlett-Packard's HFBR-0400 SMA Series transmitters and receivers.

The HFBR-0400 SMA Evaluation Kit contains the following items:

- One HFBR-1402 transmitter
- One HFBR-2402 five megabaud TTL receiver
- Two metres of SMA connectored 1000 μm plastic core fiber optic cable
- HFBR-0400 Series data sheets
- HP Application Bulletin 73

To order an SMA Evaluation Kit, please specify HFBR-0400, Quantity 1.

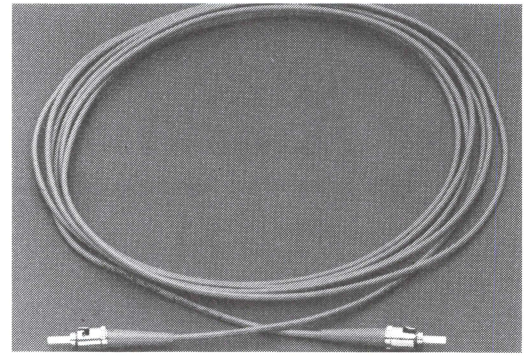


ST Evaluation Cables

Hewlett-Packard offers six different ST connectored cables, available for prototyping purposes. These simplex cables use an ST Connector with a precision ceramic ferrule. One and ten metre simplex cables are available with 62.5/125 μm, 100/140 μm, and 50/125 μm fiber sizes. To order any of these cables, please select the desired part number found below:

For example, to order two connectored simplex cables with 62.5/125 μm fiber, and ST connectors with ceramic ferrules, each ten metres long, specify:

HFBR-BXS010 Quantity: 2



ST CABLE SELECTION MATRIX

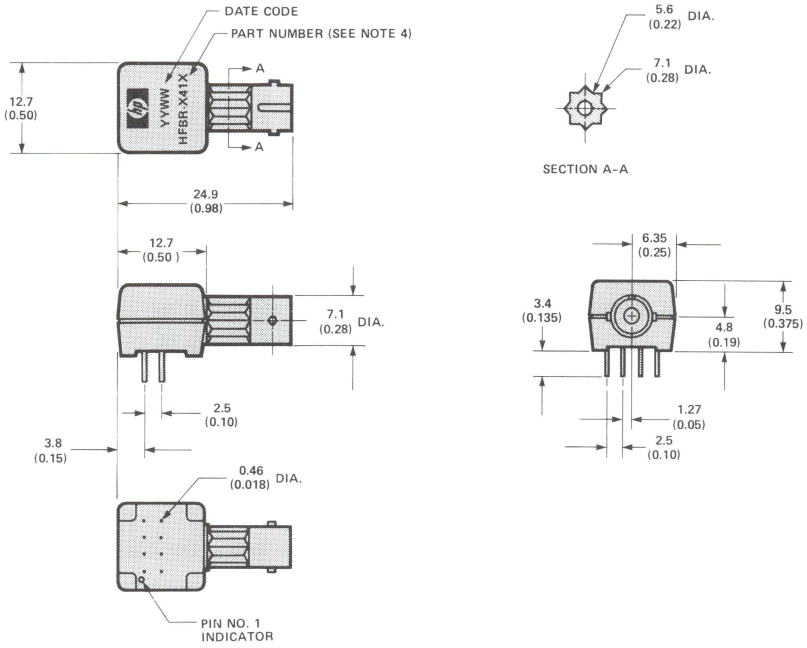
	Fiber Size (μm)			Connector	Cable	Length	
Part Number	**100/140**	**62.5/125**	**50/125**	**ST-Ceramic**	**Simplex**	**1 metre**	**10 metres**
HFBR-AXS001	X			X	X	X	
HFBR-AXS010	X			X	X		X
HFBR-BXS001		X		X	X	X	
HFBR-BXS010		X		X	X		X
HFBR-CXS001			X	X	X	X	
HFBR-CXS010			X	X	X		X

Because our ST evaluation cables are short in length, optical attenuation will be insignificant. The optical loss throughout the cable will typically be 0.5 dB, attributable to the ST Connectors on each end of the cable. It should be noted that Hewlett-Packard's HFBR-0400 ST Series transmitter and receiver specifications already account for losses through the ST Connectors.

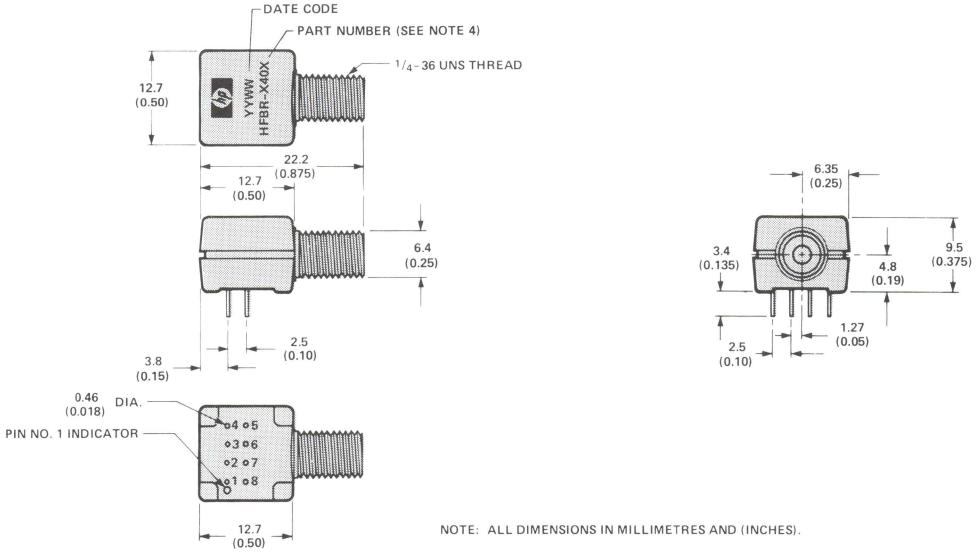
For longer distance cable lengths, mechanical and optical parameters can be guaranteed by a variety of cable suppliers. For technical information about ST Connectors, and a listing of ST connectored cable suppliers, please refer to Technical Brief 105, or call your local HP Components Field Sales Engineer.

Mechanical Dimensions

HFBR-0400 ST SERIES

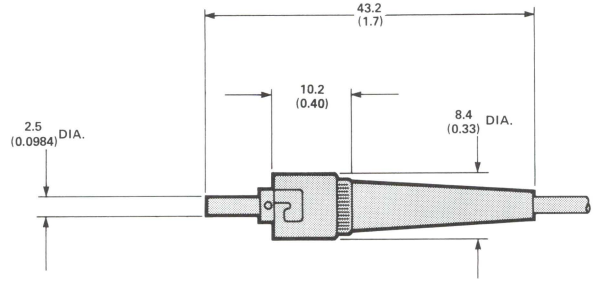


HFBR-0400 SMA SERIES



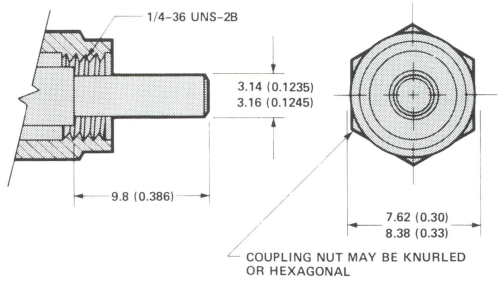
NOTE: ALL DIMENSIONS IN MILLIMETRES AND (INCHES).

ST CONNECTOR (See note 3)

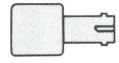


SMA CONNECTOR

(Used on HP's 100/140 μm fiber optic cable assemblies)



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES AND (INCHES).
2. FOR APPLICATIONS WITH SPACE CONSTRAINTS, THE HFBR-0400 ST AND SMA SERIES PACKAGE CAN BE SUPPLIED WITHOUT THE UPPER AND LOWER HOUSING (SEE FIGURE 1). FOR MECHANICAL DIMENSIONS, PLEASE SEE YOUR HP COMPONENTS FIELD SALES ENGINEER. THE DIMENSIONS ARE SIMILAR TO THE HFBR-0200.
3. FOR THE ST CONNECTOR SHOWN ABOVE, THE CORRESPONDING AT&T PART NUMBERS ARE P2020A-C-125, P2030A-C-125, P2020A-A-125, AND P2030A-C-140.
4. COLOR CODING; PART MARKING IS IN RED FOR HFBR-14XX TRANSMITTERS AND BLACK FOR HFBR-24XX RECEIVERS. THE PORTS ARE SHADED AS SHOWN BELOW.



TRANSMITTERS

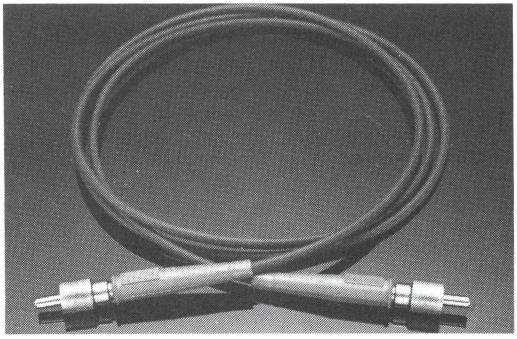
RECEIVERS

HEWLETT PACKARD

GLASS FIBER OPTIC CABLE/CONNECTOR ASSEMBLIES

Features

- **SMA CONNECTORS OR UNCONNECTORED**
- **CONNECTORS FACTORY INSTALLED AND TESTED**
- **SIMPLEX OR DUPLEX CABLE WITH 100/140 μm GLASS FIBER**
- **UL RECOGNIZED COMPONENT PASSES UL VW-1 FLAME RETARDANCY SPECIFICATION***
- **RUGGED TIGHT JACKET CONSTRUCTION**
- **PARAMETERS OPTIMIZED FOR LOCAL DATA COMMUNICATIONS**
- **BANDWIDTH: 40 MHz AT 1 km**



Description

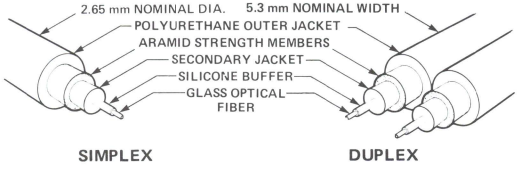
SMA connectored cable assemblies are intended for use with the HFBR-0400 SMA Series transmitters and receivers. These cables are available in standard lengths, as shown in the cable assembly ordering guide. Unconnectored 100/140 μm fiber optic cable is also available.

The simplex cable is constructed of a single graded index glass fiber surrounded by a silicone buffer, secondary jacket, and aramid strength members. The combination is covered with a scuff resistant polyurethane outer jacket.

The duplex cable has two glass fibers each in a cable of construction similar to the simplex cable, joined with a web. The individual channels are identified by a marking on one channel of the cable.

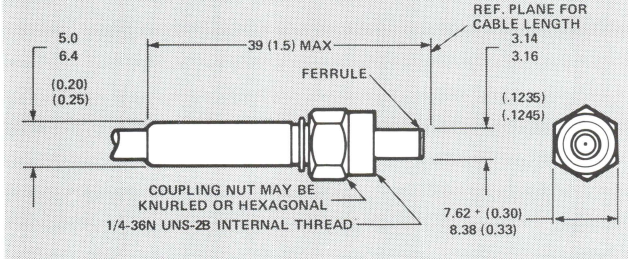
*UL File Number E84364

Fiber Optic Cable Construction



The cable's resistance to mechanical abuse, safety in flammable environments, and absence of electromagnetic interference effects may make the use of conduit unnecessary. However, the light weight and high strength of the cables allows them to be drawn through most electrical conduits. The connectors must be protected during installation by a pulling grip such as Kellems 033-29-003.

Mechanical Dimensions



SMA STYLE CONNECTOR

CABLE LENGTH TOLERANCE

Cable Length (Metres)	Tolerance
1-10	+10/-0 %
11-100	+1/-0 Metre
> 100	+1/-0 %

NOTES:
1. DIMENSIONS ARE IN mm (INCHES).
2. FIBER END IS LOCKED FLUSH WITH FERRULE FACE.

CAUTION:
1. COUPLING NUT SHOULD NOT BE OVERTIGHTENED: TORQUE 0.05 TO 0.1 UNITS N·m OVER TIGHTENING MAY CAUSE EXCESSIVE FIBER MISALIGNMENT OR PERMANENT DAMAGE.
2. GOOD SYSTEM PERFORMANCE REQUIRES CLEAN FERRULE FACES TO AVOID OBSTRUCTING THE OPTICAL PATH. CLEAN COMPRESSED AIR OFTEN IS SUFFICIENT TO REMOVE PARTICLES. A COTTON SWAB SOAKED IN METHANOL OR FREON* MAY ALSO BE USED.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Note
Relative Humidity at $T_A = 70°C$			95	%	13
Storage Temp.	T_S	-40	+85	°C	
Operating Temp.	T_A	-20	+85		
Bend Radius, No Load	r	25		mm	10
Flexing		50K		Cycles	1

Parameter		Symbol	Min.	Max.	Units	Note
Crush Load		F_C		200	N	2, 8
Impact		m		1.5	kg	3
		h		0.15	m	
Tensile Force	on Cable	F_T		300	N	9, 8
	on Connector/Cable			100		

Mechanical/Optical Characteristics -20° C to +85° C Unless Otherwise Specified.

Parameter		Symbol	Min.	Typ.[6]	Max.	Units	Conditions	Fig.	Note
Numerical Aperture		N.A.		0.3		—	$\lambda = 820$ nm, $\ell \geq 300$m		4
Attenuation		α_O	3.5	4.5	8	dB/Km	$\lambda = 820$ nm		7, 12
Bandwidth @ 1 km		BW	20	40		MHz	$\lambda = 820$ nm (LED)		5, 14
Travel Time Constant		I/V		5		ns/m	$\lambda = 820$ nm		11
Optical Fiber Core Diameter		D_C		100		μm			
Cladding Outside Diameter		D_{CL}		140					
Index Grading Coefficient		g		2		—			
Cable Structural Strength		F_C		1800		N			8
Mass per Unit Length	Single Channel	m/ℓ		6		kg/km			
	Dual Channel			12					
Cable Leakage Current		I_L		30		nA	50KV, $\ell = 0.3$m		

Notes:

1. 180° bending at minimum bend radius, with 10N tensile load.
2. Force applied on 2.5 mm diameter mandrel laid across the cable on a flat surface, for 100 hours, followed by flexure test.
3. Tested at 1 impact according to DOD-STD-1678, Method 2030, Procedure 1.
4. Fiber N.A. is measured at the end of 2 metres of mode stripped fiber, using the far field pattern. N.A. is defined as the sine of the half angle, determined at 5% of the peak intensity point.
5. Bandwidth is measured with a pulsed LED source ($\lambda = 820$ nm), and varies as $\ell^{-0.85}$, where ℓ is the length of the fiber (km). Pulse dispersion and bandwidth are approximately inversely related.
6. Typical values are at $T_A = 25°C$.
7. Fixed losses (length independent) are included in Transmitter/Receiver optical specifications.
8. One Newton equals approximately 0.225 pounds force.
9. Short term, ≤ 1 hr.
10. The probability of a fiber weak point occurring at a point of maximum bend is small, consequently the risk of fiber breakage from exceeding the maximum curvature is extremely low.
11. Travel time constant is the reciprocal of the group velocity for propagation of optical power. Group velocity, $V = \lambda/n$ where λ = velocity of light in space = 3×10^8m/s and n = effective core index of refraction.
12. For lower attenuation cable consult local HP sales office.
13. This applies to cable only.
14. For wider bandwidth cable consult local HP sales office.

Cable Assembly Ordering Guide

The desired fiber optic cable assembly can be identified by examining the part number description in Figure 1. To minimize delivery turnaround time, fixed lengths of cable have been adopted. The standard offerings of connectored and unconnectored glass fiber optic cables are listed below.

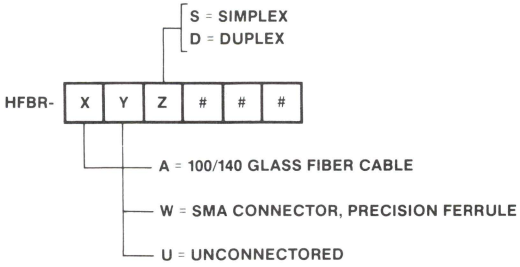


Figure 1. Part Number Description for SMA Connectored Cables and Unconnectored Cables

		SMA AND UNCONNECTORED CABLES[1, 2]											
Part Number		Fiber Size	Connector Style		Cable Type		Cable Length						
		100/140 μm	SMA	Uncon-nectored	Single Channel	Dual Channel	1M	5M	10M	25M	50M	100M	1000M
	HP Code	A	W	U	S	D	001	005	010	025	050	100	1KM
HFBR-AWS001		x	x		x		x						
HFBR-AWS005		x	x		x			x					
HFBR-AWS010		x	x		x				x				
HFBR-AWS025		x	x		x					x			
HFBR-AWS050		x	x		x						x		
HFBR-AWS100		x	x		x							x	
HFBR-AWD005		x	x			x		x					
HFBR-AWD010		x	x			x			x				
HFBR-AWD025		x	x			x				x			
HFBR-AWD050		x	x			x					x		
HFBR-AWD100		x	x			x					x		
HFBR-AUS100		x		x	x							x	
HFBR-AUS1KM		x		x	x								x
HFBR-AUD100		x		x		x						x	
HFBR-AUD1KM		x		x		x							x

Notes:

1. Please contact your local HP sales office for delivery and pricing of non-standard lengths of SMA connectored cables, and unconnectored cables with 100/140 μm fiber.
2. For cables with HFBR-4000 (HP Style) connectors, the standard offerings are identical to the SMA connectored cable offerings. To order, replace the W (SMA) in the part number with H (HFBR-4000). For example, for one piece of 100/140 μm duplex fiber cable, 5 metres long, with HFBR-4000 connectors, specify HFBR-AHD005, Quantity 1.

Examples:

A. To order three duplex 100/140 μm cable assemblies, 100 metres long each, with SMA connectors, specify: HFBR-AWD100, Quantity 3.
B. To order one simplex 100/140 μm cable assembly, 10 metres long, with SMA connectors, specify: HFBR-AWS010, Quantity 1.
C. To order two duplex 100/140 μm cable assemblies, 1000 metres long each, unconnectored, specify: HFBR—AUD1KM, Quantity 2.

HEWLETT PACKARD

SNAP-IN FIBER OPTIC LINKS TRANSMITTERS, RECEIVERS, CABLE AND CONNECTORS

HFBR-0500 SERIES

Features

- GUARANTEED LINK PERFORMANCE OVER TEMPERATURE
  High Speed Links: dc to 5 MBd
  Extended Distance Links up to 82 m
  Low Current Links: 6 mA Peak Supply Current for an 8 m Link
  Photo Interrupters
- LOW COST PLASTIC DUAL-IN-LINE PACKAGE
- EASY FIELD CONNECTORING
- EASY TO USE RECEIVERS:
  Logic Compatible Output Level
  Single +5 V Receiver Power Supply
  High Noise Immunity
- LOW LOSS PLASTIC CABLE:
  Selected Super Low Loss Simplex Cable
  Simplex and Zip Cord Style Duplex Cable

Applications

- HIGH VOLTAGE ISOLATION
- SECURE DATA COMMUNICATIONS
- REMOTE PHOTO INTERRUPTER
- LOW CURRENT LINKS
- INTER/INTRA-SYSTEM LINKS
- STATIC PROTECTION
- EMC REGULATED SYSTEMS (FCC, VDE)

Description

The HFBR-0500 series is a complete family of fiber optic link components for configuring low-cost control, data transmission, and photo interrupter links. These components are designed to mate with plastic snap-in connectors and low-cost plastic cable.* Link design is simplified by the logic compatible receivers and the ease of connectoring the plastic fiber cable. The key parameters of links configured with the HFBR-0500 family are fully guaranteed.

* Cable is available in standard low loss and selected super low loss varieties.

Link Selection Guide

GUARANTEED LINKS

		Guaranteed Link Length 0-70° C		Typical Link Lengths 25° C				
	Data Rate	Standard Cable	Improved Cable	Standard Cable	Improved Cable	Transmitter	Receiver	Page
5 MBd Link	5 MBd	12	17	35 m	40 m	HFBR-1510	HFBR-2501	8-62
1 MBd Link	1 MBd	24	34	50 m	65 m	HFBR-1502	HFBR-2502	8-64
Low Current Link	40 kBd	8	11	30 m	35 m	HFBR-1512	HFBR-2503	8-66
Extended Distance Link	40 kBd	60	82	100 m	125 m	HFBR-1512	HFBR-2503	8-66
Photo Interrupter Link	20 kHz 500 kHz	N/A N/A	N/A N/A	N/A N/A	N/A N/A	HFBR-1512 HFBR-1502	HFBR-2503 HFBR-2502	8-68 8-68

Component Selection Guide

TRANSMITTERS

	Minimum Output Optical Power 0 to 70° C	Peak Emission Wavelength	Page
HFBR-1510	–16.5 dBm	665 nm	11
HFBR-1502	–13.6 dBm	665 nm	11
HFBR-1512	–13.6 dBm	665 nm	11

RECEIVERS

	Sensitivity 0 to 70° C	Data Rate	Page
HFBR-2501	–21.6 dBm	5 MBd	12
HFBR-2502	–24 dBm	1 MBd	12
HFBR-2503	–39 dBm	40 kBd	14

CABLES

Please refer to page 15 (of the Versatile Link Fiber Optics Data Sheet) for cable specifications.

CONNECTORS

Page 17

HFBR-4501 Gray Connector/Crimp Ring
HFBR-4511 Blue Connector/Crimp Ring
HFBR-4595 Polishing Kit
Polishing Fixture — Abrasive Paper
HFBR-4596 Polishing Fixture
Bulkhead Feedthrough/In-Line Splice
HFBR-4505 Gray
HFBR-4515 Blue

Mechanical Dimensions

Page 19

5 MBd Link

HFBR-1510 AND HFBR-2501

The dc to 5 MBd link is guaranteed over temperature to operate up to 17 m with a transmitter drive current of 60 mA. This link uses the 665 nm HFBR-1510 Transmitter, the HFBR-2501 Receiver, and Plastic Cable. The receiver compatible with LSTTL/TTL/CMOS logic levels offers a choice of internal pull-up or open collector output.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Max.	Units	Ref.
Ambient Temperature	T_A	0	70	°C	
Transmitter Peak Forward Current	$I_{F\,PK}$	10	750	mA	Note 1
Avg. Forward Current	$I_{F\,AV}$		60	mA	
Receiver Supply Voltage	V_{CC}	4.75	5.25	V	Note 2
Fan-Out (TTL)	N		5		

SYSTEM PERFORMANCE Using Standard Cable under recommended operating conditions unless otherwise specified.

Parameter	Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Data Rate		dc		5	MBd	BER ≤ 10^{-9}	
Transmission Distance Standard Cable	ℓ	12			m	I_{FPK} = 60 mA, 0–70° C	
		17	35		m	I_{FPK} = 60 mA, 25° C	
Transmission Distance Improved Cable		17			m	I_{FPK} = 60 mA, 0–70° C	
		24	40		m	I_{FPK} = 60 mA, 25° C	
Propagation Delay	t_{PLH}		80	140	ns	R_L = 560 Ω, C_L = 30 pF	Fig. 4, 5
	t_{PHL}		50	140	ns	P_R = –21.6≤P_R≤–9.5dBm	Note 3
Pulse Width Distortion	t_D		30		ns	P_R = –15 dBm R_L = 560 Ω, C_L = 30 pF	Fig. 4, 6 Note 4
EMI Immunity			8000		V/m	BER ≤ 10^{-9}	

Notes:
1. For I_{FPK} > 80 mA, the duty factor must be such as to keep I_{FAV} ≤ 80 mA. In addition, for I_{FPK} > 80 mA, the following rules for pulse width apply: I_{FPK} ≤ 160 mA: Pulse width ≤ 1 ms I_{FPK} > 160 mA: Pulse width ≤ 1 μs
2. It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from pin 3 to pin 4 of the receiver. Total lead length between both ends of the capacitor and the pins should not exceed 20 mm.
3. The propagation delay of 1 m of cable (5 ns) is included.
4. $T_D = t_{PLH} - t_{PHL}$.
5. Typical data is at 25° C, V_{CC} = 5 V.

Link Design Considerations

The HFBR-1510/2501 Transmitter/Receiver pair is guaranteed for operation at data rates up to 5 MBd over link distances from 0 to 12 metres with standard cable and from 0 to 17 metres with improved cable. The value of transmitter drive current, I_F, depends on the link distance as shown in Figures 2 and 3. Note that there is an upper as well as a lower limit on the value of I_F for any given distance. The dotted lines in Figures 2 and 3 represent pulsed operation. When operating in the pulsed mode, the conditions in Note 1 must be met. After selecting a value of the transmitter drive current I_F, the value of R_1 in Figure 1 can be calculated as follows:

$$R_1 = \frac{V_{CC} - V_F}{I_F}$$

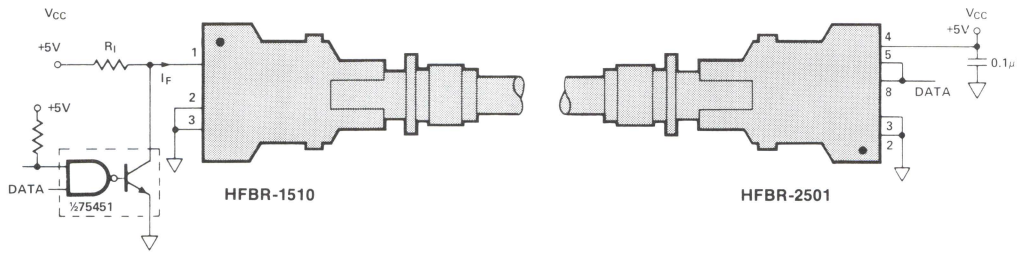


Figure 1. Typical Circuit Operation (5 MBd ≤ 12 m)

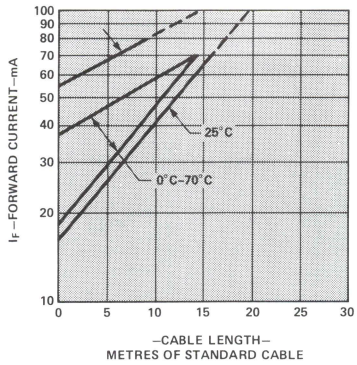


Figure 2. Guaranteed System Performance with HFBR-1510 and HFBR-2501, Standard Cable

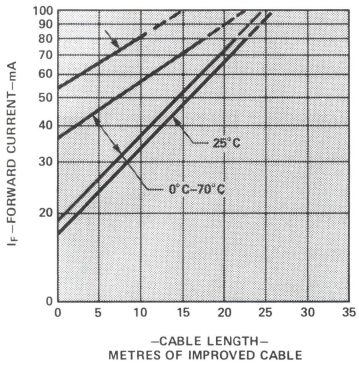


Figure 3. Guaranteed System Performance with HFBR-1510 and HFBR-2501, Improved Cable

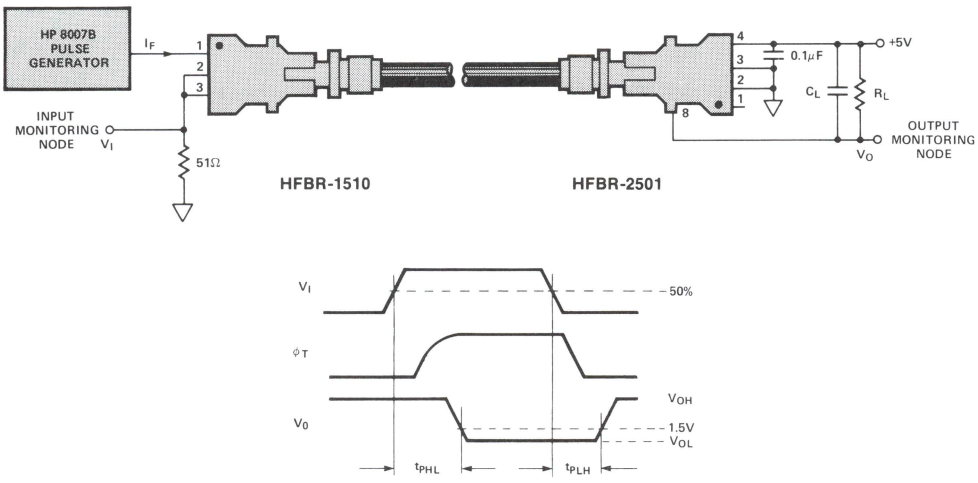


Figure 4. A.C. Test Circuit

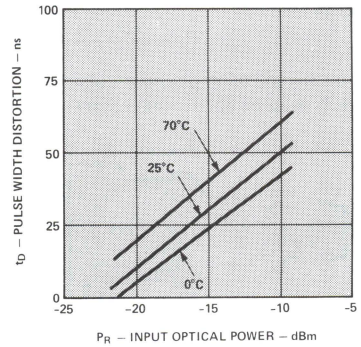


Figure 5. HFBR-1510/2501 Link Pulse Width Distortion vs. Optical Power

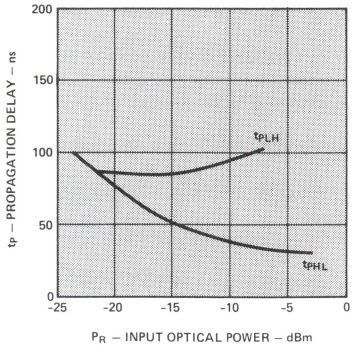


Figure 6. HFBR-1510/2501 Link Propagation Delay vs. Optical Power

1 MBd Link HFBR-1502 AND HFBR-2502

The dc to 1 MBd link is guaranteed over temperature to operate from 0 to 34 m with a transmitter drive current of 60 mA. This link uses the 665 nm HFBR-1502 Transmitter, the HFBR-2502 Receiver, and Improved Cable. The receiver is compatible with LSTTL/TTL/CMOS logic levels and offers a choice of an internal pull-up or open collector output.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Max.	Units	Ref.
Ambient Temperature	T_A	0	70	°C	
Transmitter Peak Forward Current	$I_{F\,PK}$	10	750	mA	Note 1
Avg. Forward Current	$I_{F\,AV}$		60	mA	
Receiver Supply Voltage	V_{CC}	4.75	5.25	V	Note 2
Fan-Out (TTL)	N		5		

SYSTEM PERFORMANCE Using Standard Cable under recommended operating conditions unless otherwise specified.

Parameter	Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Data Rate		dc		1	MBd	BER ≤ 10^{-9}	
Transmission Distance Standard Cable	ℓ	24			m	I_{FPK} = 60 mA, 0–70° C	
		30	50		m	I_{FPK} = 60 mA, 25° C	
Transmission Distance Improved Cable	ℓ	34			m	I_{FPK} = 60 mA, 0–70° C	
		41	65		m	I_{FPK} = 60 mA, 25° C	
Transmission Distance Standard Cable	ℓ	30				I_{FPK} = 120 mA, 0–70° C	
		36	60			I_{FPK} = 120 mA, 25° C	
Transmission Distance Improved Cable	ℓ	41				I_{FPK} = 120 mA, 0–70° C	
		50	75			I_{FPK} = 120 mA, 25° C	
Propagation Delay	t_{PLH}		180	250	ns	R_L = 560 Ω, C_L = 30 pF	Fig. 4, 5
	t_{PHL}		100	140	ns	P_R = −24 dBm	Note 3
Pulse Width Distortion	t_D		80		ns	P_R = −24 dBm R_L = 560 Ω, C_L = 30 pF	Fig. 4, 6 Note 4
EMI Immunity			8000		V/m	BER ≤ 10^{-9}	

Notes: 1. For I_{FPK} > 80 mA, the duty factor must be such as to keep I_{FAV} ≤ 80 mA. In addition, for I_{FPK} > 80 mA, the following rules for pulse width apply: I_{FPK} ≤ 160 mA: Pulse width ≤ 1 ms I_{FPK} > 160 mA: Pulse width ≤ 1 μs

2. It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from pin 3 to pin 4 of the receiver. Total lead length between both ends of the capacitor and the pins should not exceed 20 mm.

3. The propagation delay of 1 m of cable (5 ns) is included. 4. $T_D = t_{PLH} - t_{PHL}$. 5. Typical data is at 25°C, V_{CC} = 5 V.

Link Design Considerations

The HFBR-1502/2502 Transmitter/Receiver pair is guaranteed for operation at data rates up to 1 MBd over link distances from 0 to 24 metres with standard cable and from 0 to 34 metres with improved cable. The value of transmitter drive current, I_F, depends on the link distance as shown in Figures 2 and 3. Note that there is a lower limit on the value of I_F for any given distance. The dotted lines in Figures 2 and 3 represent pulsed operation. When operating in the pulsed mode, the conditions in Note 1 must be met. After selecting a value of the transmitter drive current I_F, the value of R_1 in Figure 1 can be calculated as follows:

$$R_1 = \frac{V_{CC} - V_F - V_{OL}\ (75451)}{I_F}$$

For the HFBR-1502/2502 pair, the value of the capacitor, C_1 (Figure 1) must be chosen such that $R_1 C_1 \geq 75$ ns.

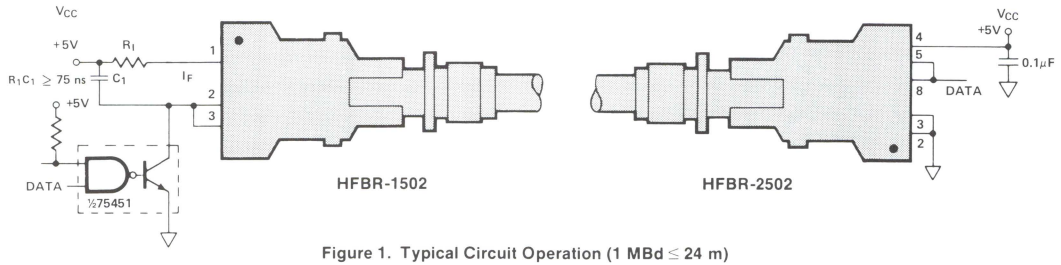


Figure 1. Typical Circuit Operation (1 MBd ≤ 24 m)

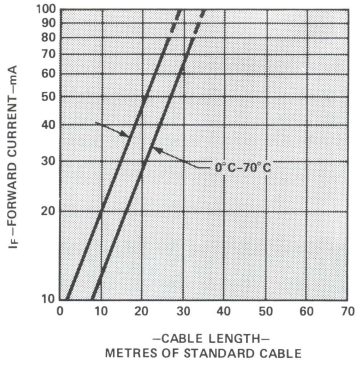


Figure 2. Guaranteed System Performance with HFBR-1502 and HFBR-2502, Standard Cable

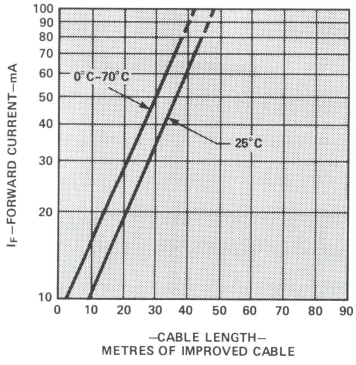


Figure 3. Guaranteed System Performance with HFBR-1502 and HFBR-2502, Improved Cable

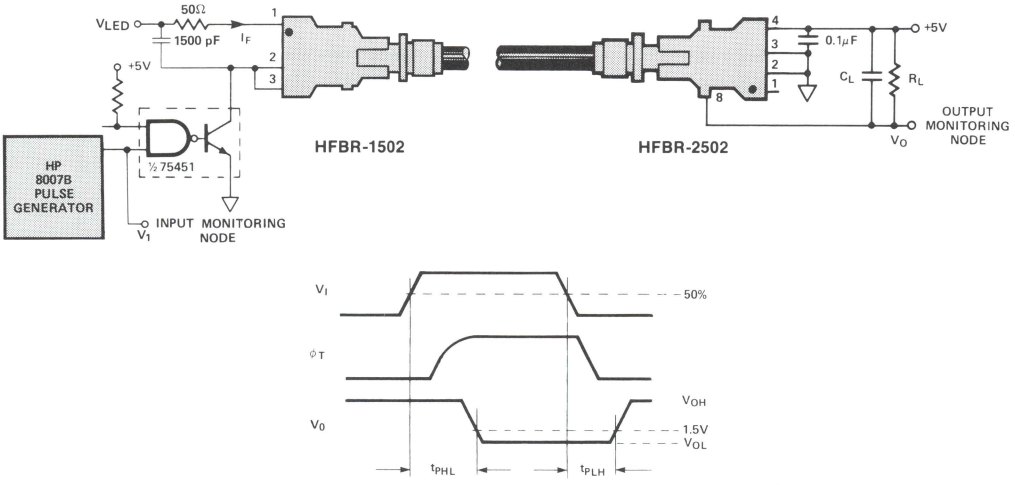


Figure 4. A.C. Test Circuit

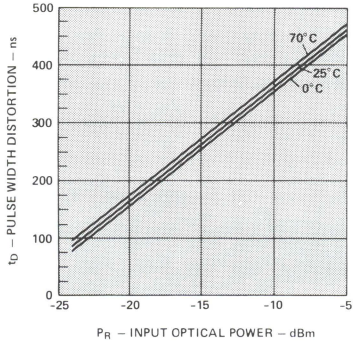


Figure 5. HFBR-1502/2502 Link Pulse Width Distortion vs. Optical Power

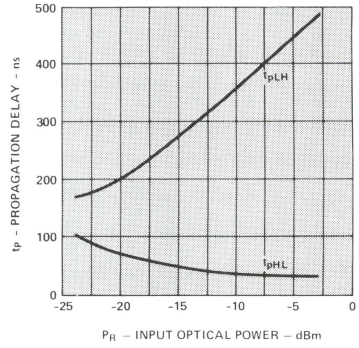


Figure 6. HFBR-1502/2502 Link Propagation Delay vs. Optical Power

Low Current/Extended Distance Link

HFBR-1512 AND HFBR-2503

The low current link requires only 6 mA peak supply current for the transmitter and receiver combined to achieve an 11 m link. Extended distances up to 82 m can be achieved at a maximum transmitter drive current of 60 mA peak. This link can be driven with TTL/LSTTL and most CMOS logic gates.

The black plastic housing of the HFBR-1512 Transmitter is designed to prevent the penetration of ambient light into the cable through the transmitter. This prevents the sensitive receiver from being triggered by ambient light pulses.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Max.	Units	Ref.
Ambient Temperature	T_A	0	70	°C	
Transmitter Peak Forward Current	$I_{F\,PK}$	2	120	mA	Note 1
Avg. Forward Current	$I_{F\,AV}$		60	mA	
Receiver Supply Voltage	V_{CC}	4.5	5.5	V	Note 2
Output Voltage	V_O		V_{CC}	V	
Fan-Out (TTL)	N		1		

SYSTEM PERFORMANCE Using Standard Cable under recommended operating conditions unless otherwise specified.

Parameter	Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Data Rate		dc		40	kBd	$t_D \leq 7.0\ \mu s$	
Transmission Distance Standard Cable	ℓ	8	30		m	$I_{FPK} = 2$ mA, 0–70° C	
		60	100		m	$I_{FPK} = 60$ mA, 0–70° C	
Transmission Distance Improved Cable	ℓ	11	35		m	$I_{FPK} = 2$ mA, 0–70° C	
		82	125		m	$I_{FPK} = 60$ mA, 0–70° C	
Propagation Delay	t_{PLH}		4		μs	$R_L = 3.3$K Ω, $C_L = 30$ pF	Fig. 4, 5
	t_{PHL}		2.5		μs	$P_R = -25$ dBm	Note 3
Pulse Width Distortion	t_D			7.0	μs	$-39 \leq P_R \leq -14$ dBm $R_L = 3.3$ KΩ, $C_L = 30$ pF	Fig. 4, 6 Note 4
Bit Error Rate	BER		10^{-9}			$P_R = -30$ dBm	
EMI Immunity			5000		V/m	$P_R = 0$ mW	

Notes:

1. For $I_{FPK} > 80$ mA, the duty factor must be such as to keep $I_{FAV} \leq 80$ mA. In addition, if $I_{FAV} > 80$ mA, then the pulse width must be equal to or less than 1 ms.
2. It is recommended that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from pin 3 to pin 4 of the receiver.
3. The propagation delay of 1 m of cable (5 ns) is included.
4. $t_D = t_{PLH} - t_{PHL}$.
5. Typical data is at 25° C, $V_{CC} = 5$ V.

Link Design Considerations

The HFBR-1512/2503 Transmitter/Receiver pair is guaranteed for operation at data rates up to 40 kBd for transmitter drives as low as 2 mA. The value of transmitter drive current, I_F, depends on the link distance as shown in Figures 2 and 3. Note that there is an upper as well as a lower limit on the value of I_F for any given distance. After selecting a value of the transmitter drive current I_F, the value of R_1 in Figure 1 can be calculated as follows:

$$R_1 = \frac{V_{CC} - V_F}{I_F}$$

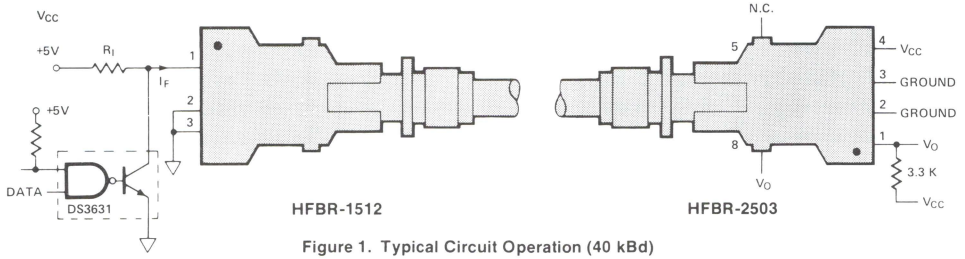


Figure 1. Typical Circuit Operation (40 kBd)

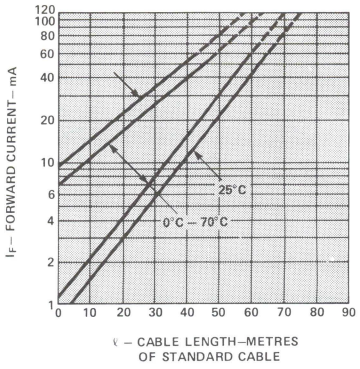


Figure 2. Guaranteed System Performance with HFBR-1512 and HFBR-2503, Standard Cable

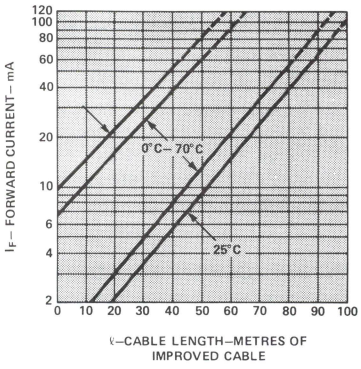
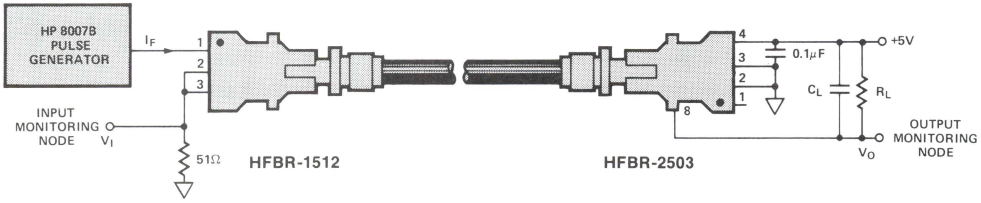


Figure 3. Guaranteed System Performance with HFBR-1512 and HFBR-2503, Improved Cable



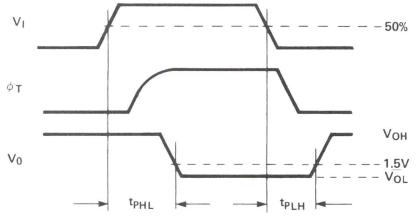


Figure 4. A.C. Test Circuit

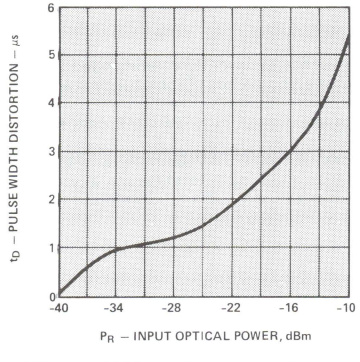


Figure 5. HFBR-1512/2503 Link Pulse Width Distortion vs. Optical Power

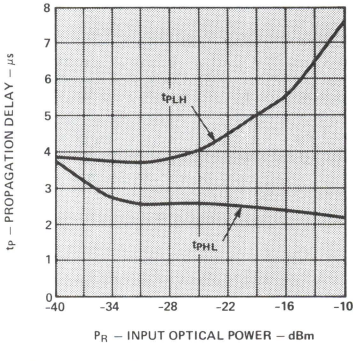


Figure 6. HFBR-1512/2503 Link Propagation Delay vs. Optical Power

Photo Interrupter Links

HFBR-1502/2502
HFBR-1512/2503

These links may be used in optical switches, shaft position sensors, and velocity sensors. They are particularly useful where high voltage, electrical noise, or explosive environments prohibit the use of electromechanical or optoelectronic sensors.

The HFBR-1512/2503 link (20 kHz) has an optical power budget of 24 dB, and the HFBR-1502/2502 link (500 kHz) budget is 10 dB. Total system losses (cable attenuation, air-gap loss, etc) must not exceed the link optical power budget.

RECOMMENDED OPERATING CONDITIONS

Parameter		Symbol	Min.	Max.	Units	Ref.
Ambient Temperature		T_A	0	70	°C	
Transmitter Peak Forward Current		$I_{F\,PK}$	10	750	mA	Note 1
Avg. Forward Current		$I_{F\,AV}$		60	mA	
Receiver Supply Voltage	HFBR-2503	V_{CC}	4.50	5.50	V	
	HFBR-2502		4.75	5.25		Note 2
Output Voltage	HFBR-2503	V_O		V_{CC}	V	
	HFBR-2502			18		
Fanout (TTL)	HFBR-2503			1		
	HFBR-2502			5		

SYSTEM PERFORMANCE

See HFBR-1502/2502 link data sheet (page 5) and HFBR-1512/2503 link data sheet (page 7) for more design information.

These specifications apply when using Standard Cable and, unless otherwise specified, under recommended operating conditions.

Parameter	Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
HFBR-1512/HFBR-2503							
Max. Count Frequency		dc		20	kHz		
Optical Power Budget		25.4			dB	I_{FPK} = 60 mA, 0–70° C	
		27.8	34		dB	I_{FPK} = 60 mA, 25° C	Note 3, 4
HFBR-1502, HFBR-2502							
Max. Count Frequency		dc		500	kHz		
Optical Power Budget		10.4			dB	I_{FPK} = 60 mA, 0–70° C	
		12.8	15.6		dB	I_{FPK} = 60 mA, 25° C	Note 3

Notes:

1. For $I_{FPK} > 80$ mA, the duty factor must be such as to keep $I_{FAV} \leq 80$ mA. In addition, for $I_{FPK} > 80$ mA, the following rules for pulse width apply:
   $I_{FPK} \leq 160$ mA: Pulse width ≤ 1 ms
   $I_{FPK} > 160$ mA: Pulse width $\leq 1\ \mu s$
2. A bypass capacitor (0.01 μF to 0.1 μF ceramic) connected from pin 3 to pin 4 of the receiver is recommended for the HFBR-2503 and essential for the HFBR-2502. For the HFBR-2502, the total lead length between both ends of the capacitor and the pins should not exceed 20 mm.
3. Optical Power Budget = P_T Min. – $P_{R(L)}$ Min. Refer to HFBR-1502/1512 data sheet, page 11; HFBR-2502 data sheet, page 12; and HFBR-2503 data sheet, page 14 for additional design information.
4. In addition to a minimum power budget, care should be taken to avoid overdriving the HFBR-2503 receiver with too much optical power. For this reason power levels into the receiver should be kept less than –13.7 dBm to eliminate any overdrive with the recommended operating conditions.
5. Typical data is at 25° C, $V_{CC} = 5$ V.

Link Design Considerations

The HFBR-1512/2503 and HFBR-1502/2502 Transmitter/Receiver pairs are intended for applications where the photo interrupter must be physically separate from the optoelectronic emitter and detector. This separation would be useful where high voltage, electrical noise or explosive environments prohibit the use of electronic devices. To ensure reliable long term operation, links designed for this application should operate with an ample optical power margin $\alpha_M \geq 3$ dB, since the exposed fiber ends are subject to environmental contamination that will increase the optical attenuation of the slot with time. A graph of air gap separation versus attenuation for clean fiber ends with minimum radial error ≤ 0.005 inches (0.127 mm) and angular error ($\leq 3.0°$) is provided in Figure 2. The following equations can now be used to determine the transmitter output power, P_T, for both the overdrive and minimum drive cases. Overdrive is defined as a condition where excessive optical power is delivered to the receiver. The first equation enables the maximum P_T that will not result in receiver overdrive to be calculated for a predetermined link length and slot attenuation. The second equation defines the minimum P_T allowed for link operation.

$$P_T\,(MAX) - P_R\,(MAX) \leq \alpha_{O\ MIN}\ell + \alpha_{SLOT} \qquad \text{Eq. 1}$$

$$P_T\,(MIN) - P_{RL}\,(MIN) \geq \alpha_{O\ MAX}\ell + \alpha_{SLOT} + \alpha_M \qquad \text{Eq. 2}$$

Once P_T (MIN) has been determined in the second equation for a specific link length (ℓ), slot attenuation (α_{SLOT}) and margin (α_M), Figure 3 can then be used to find I_F.

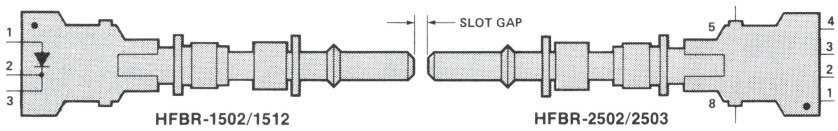


Figure 1. Typical Slot Interrupter Configuration. Refer to 1 MBd or Low Current Links for Schematic Diagrams

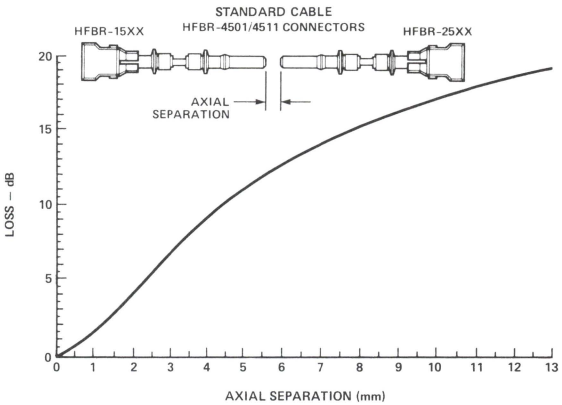


Figure 2. Typical Loss vs. Axial Separation

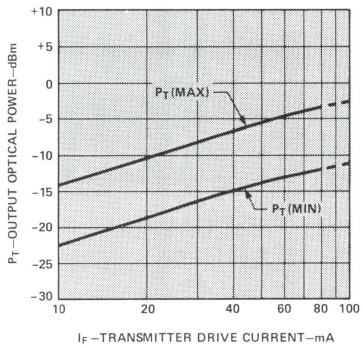


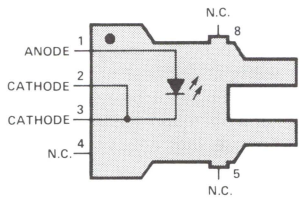
Figure 3. Typical HFBR-1502/1512 Optical Output Power vs. Transmitter I_F (0—70° C)

665 nm Transmitters

HFBR-1502/HFBR-1510 and HFBR-1512

The HFBR-1510/1502/1512 Transmitter modules incorporate a 665 nm LED emitting at a low attenuation wavelength for the HFBR-3510/3610 plastic fiber optic cable. The transmitters can be easily interfaced to standard TTL logic. The optical power output of the HFBR-1510/1512/1502 is specified at the end of 0.5 m of cable. The HFBR-1512 output optical power is tested and guaranteed at low drive currents.

HFBR-1510/1512/1502 Transmitter



Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Operating Temperature		T_A	0	+70	°C	
Lead Soldering Cycle	Temp.			260	°C	Note 1
	Time			10	sec.	
Peak Forward Input Current		$I_{F\,PK}$		1000	mA	Note 2
Average Forward Input Current		$I_{F\,AV}$		80	mA	
Reverse Input Voltage		V_R		5	V	

Electrical/Optical Characteristics 0° C to +70° C Unless Otherwise Specified

Parameter		Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Transmitter Output Optical Power	HFBR-1510	P_T	-16.5		-7.6	dBm	I_F = 60 mA, 0–70° C	
			-14.1		-8.4	dBm	I_F = 60 mA, 25° C	
	HFBR-1502 and HFBR-1512	P_T	-13.6		-4.5	dBm	I_F = 60 mA, 0–70° C	Fig. 2
			-11.2		-5.4	dBm	I_F = 60 mA, 25° C	Note 4
	HFBR-1512	P_T	-35.5			dBm	I_F = 2 mA, 0–70° C	Note 3
Output Optical Power Temperature Coefficient		$\frac{\Delta P_T}{\Delta T}$		-0.026		dB/° C		
Peak Emission Wavelength		λ_{PK}		665		nm		
Forward Voltage		V_F	1.45	1.67	2.02	V	I_F = 60 mA	
Forward Voltage Temperature Coefficient		$\frac{\Delta V_F}{\Delta T}$		-1.37		mV/° C		Fig. 1
Effective Diameter		D_T		1		mm		
Numerical Aperture		N.A.		0.5				
Reverse Input Breakdown Voltage		V_{BR}	5.0	12.4		V	I_F = -10 μA, T_A = 25° C	
Diode Capacitance		C_O		86		pF	V_F = 0, f = 1 MHz	
Rise and Fall Time		t_R, t_F		50		ns	10% to 90%	

Notes:
1. 1.6 mm below seating plane.
2. 1 μs pulse, 20 μs period.
3. Measured at the end of 0.5 m standard Fiber Optic Cable with large area detector.
4. Optical power, P (dBm) = 10 Log P (μW)/1000 μW.
5. Typical data is at 25° C.

WARNING. When viewed under some conditions, the optical port of the Transmitter may expose the eye beyond the Maximum Permissible Exposure recommended in ANSI Z-136-1, 1981. Under most viewing conditions there is no eye hazard.

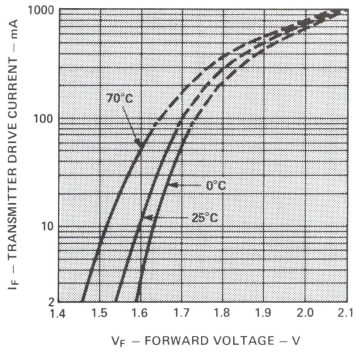


Figure 1. Typical Forward Voltage vs. Drive Current for HFBR-1510/1502/1512

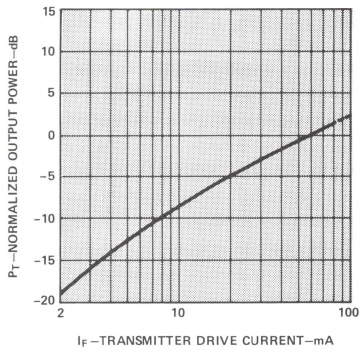


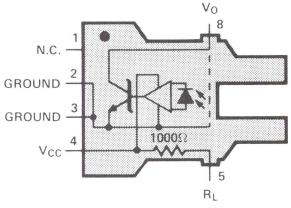
Figure 2. Normalized HFBR-1510/1502/1512 Typical Output Optical Power vs. Drive Current

Receivers

HFBR-2501 (5 MBd) and HFBR-2502 (1 MBd)

The HFBR-2501/2502 Receiver modules feature a shielded integrated photodetector and wide bandwidth DC amplifier for high EMI immunity. A Schottky clamped open-collector output transistor allows interfacing to common logic families and enables "wired-OR" circuit designs. The open collector output is specified up to 18V. An integrated 1000 ohm resistor internally connected to V_{CC} may be externally jumpered to provide a pull-up for ease-of-use with +5V logic. The combination of high optical power levels and fast transitions falling edge could result in distortion of the output signal (HFBR-2502 only), that could lead to multiple triggering of following circuitry.

HFBR-2501/2502 Receiver



Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	-40	+75	°C	
Operating Temperature		T_A	0	+70	°C	
Lead Soldering Cycle	Temp			260	°C	Note 1
	Time			10	sec	
Supply Voltage		V_{CC}	-0.5	7	V	Note 6
Output Collector Current		I_O		25	mA	
Output Collector Power Dissipation		P_{OD}		40	mW	
Output Voltage		V_O	-0.5	18	V	
Pullup Voltage		V_{RL}	-0.5	V_{CC}	V	

Electrical/Optical Characteristics $0°C$ to $+70°C$, $4.75 \leq V_{CC} \leq 5.25$ Unless Otherwise Specified

Parameter		Symbol	Min.	Typ.[5]	Max.	Units	Conditions	Ref.
Receiver Input Optical Power Level for Logic "0"	HFBR-2501	$P_{R(L)}$	-21.6		-9.5	dBm	0-70° C, V_{OL} = 0.5 V I_{OL} = 8 mA	Note 2, 3
			-21.6		-8.7	dBm	25° C, V_{OL} = 0.5 V I_{OL} = 8 mA	
	HFBR-2502	$P_{R(L)}$	-24			dBm	0-70° C, V_{OL} = 0.5 V I_{OL} = 8 mA	
			-24			dBm	25° C, V_{OL} = 0.5 V I_{OL} = 8 mA	
Input Optical Power Level for Logic "1"		$P_{R(H)}$			-43	dBm	V_{OH} = 5.25 V, $I_{OH} \leq 250\ \mu A$	Note 2
High Level Output Current		I_{OH}		5	250	μA	V_O = 18 V, P_R = 0	Note 4
Low Level Output Voltage		V_{OL}		0.4	0.5	V	I_{OL} = 8 mA, $P_R = P_{RL\ MIN}$	Note 4
High Level Supply Current		I_{CCH}		3.5	6.3	mA	V_{CC} = 5.25 V, P_R = 0 μW	Note 4
Low Level Supply Current		I_{CCL}		6.2	10	mA	V_{CC} = 5.25 V, P_R = -12.5 dBm	Note 4
Effective Diameter		D_R		1		mm		
Numerical Aperture		N.A.R		0.5				
Internal Pull-Up Resistor		R_L	680	1000	1700	Ohms		

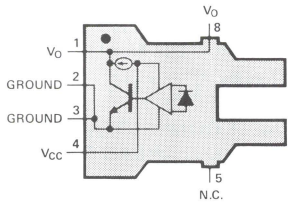
Notes:
1. 1.6 mm below seating plane.
2. Optical flux, P (dBm) = 10 Log P (μW)/1000 μW.
3. Measured at the end of standard Fiber Optic Cable with large area detector.
4. R_L is open.
5. Typical data is at 25° C, V_{CC} = 5 V.
6. It is essential that a bypass capacitor 0.01 μF to 0.1 μF be connected from pin 3 to pin 4 of the receiver. Total lead length between both ends of the capacitor and the pins should not exceed 20 mm.

High Sensitivity Receiver

HFBR-2503

The blue plastic HFBR-2503 Receiver module has a sensitivity of –39 dBm. It features an integrated photodetector and DC amplifier for high EMI immunity. The output is an open collector with a 150 μA internal current source pull-up and is compatible with TTL/LSTTL and most CMOS logic families. For minimum rise time add an external pull-up resistor of at least 3.3K ohms. V_{CC} must be greater than or equal to the supply voltage for the pull-up resistor.

HFBR-2503 Receiver



Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Ref.
Storage Temperature		T_S	–40	+75	°C	
Operating Temperature		T_A	0	+70	°C	
Lead Soldering Cycle	Temp			260	°C	Note 1
	Time			10	sec	
Supply Voltage		V_{CC}	–0.5	7	V	Note 7
Output Collector Current (Average)		I_O	–1	5	mA	
Output Collector Power Dissipation		P_{OD}		25	mW	
Output Voltage		V_O	–0.5	V_{CC}	V	

Electrical/Optical Characteristics 0° C to +70° C, 4.5 ≤ V_{CC} ≤ 5.5 Unless Otherwise Specified

Parameter		Symbol	Min.	Typ. (5)	Max.	Units	Conditions	Ref.
Receiver Input Optical Power Level for Logic "0"	HFBR-2503	$P_{R(L)}$	–39		–13.7	dBm	0-70° C, $V_O = V_{OL}$ I_{OL} = 3.2 mA	Note 2, 3, 4
			–39		–13.3	dBm	25° C, $V_O = V_{OL}$ I_{OL} = 3.2 mA	
Input Optical Power Level for Logic "1"		$P_{R(H)}$			–53	dBm	V_{OH} = 5.5V, $I_{OH} \leq 40$ μA	Note 2
High Level Output Voltage		V_{OH}	2.4			V	$I_{OH} = -40$ μA, $P_R = 0$ μW	
Low Level Output Voltage		V_{OL}			0.4	V	I_{OL} = 3.2 mA, $P_R = P_{RL\ MIN}$	Note 6
High Level Supply Current		I_{CCH}		1.2	1.9	mA	V_{CC} = 5.5V, $P_R = 0$ μW	
Low Level Supply Current		I_{CCL}		2.9	3.7	mA	V_{CC} = 5.5V, $P_R \geq P_{RL}$ (MIN)	Note 6
Effective Diameter		D_R		1		mm		
Numerical Aperture		N.A.R		0.5				

Notes:
1. 1.6 mm below seating plane.
2. Optical flux, P (dBm) = 10 Log P (μW)/1000 μW.
3. Measured at the end of the standard Fiber Optic Cable with large area detector.
4. Because of the very high sensitivity of the HFBR-2503, the digital output may switch in response to ambient light levels when a cable is not occupying the receiver optical port. The designer should take care to filter out signals from this source if they pose a hazard to the system.
5. Typical data is at 25° C, V_{CC} = 5 V.
6. Including current in 3.3K pull-up resistor.
7. It is recommended that a bypass capacitor 0.01 μF to 0.1 μF ceramic be connected from pin 3 to pin 4 of the receiver.

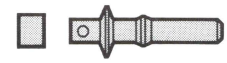
Snap-in Fiber Optic Connector, Bulkhead Feedthrough/Splice and Polishing Tools

HFBR-4501/4511 CONNECTORS
HFBR-4505/4515 BULKHEAD FEEDTHROUGHS

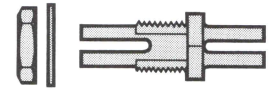
The HFBR-4501 and HFBR-4511 snap-in connectors terminate low cost plastic fiber cable and mate with the Hewlett-Packard HFBR-0500 family of fiber optic transmitters and receivers. They are quick and easy to install. The metal crimp ring provides strong and stable cable retention and the polishing technique ensures a smooth optical finish which results in consistently high optical coupling efficiency.

The HFBR-4505 and HFBR-4515 bulkhead feedthroughs mate two snap-in connectors and can be used either as an in-line splice or as a panel feedthrough for plastic fiber cable. The connector to connector loss is low and repeatable.

HFBR-4501 (GRAY)/4511 (BLUE) CONNECTOR



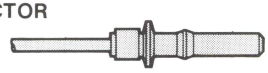
HFBR-4505 (GRAY)/4515 (BLUE) BULKHEAD FEEDTHROUGH



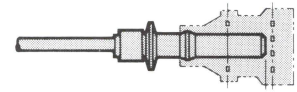
HFBR-4595 POLISHING KIT

Applications

- **CONNECTOR**

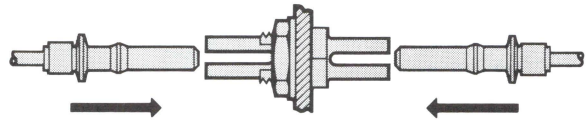


TERMINATION FOR HEWLETT-PACKARD PLASTIC FIBER OPTIC CABLE

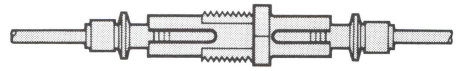


INTERFACE TO HEWLETT-PACKARD HFBR-15XX/25XX SNAP-IN FIBER OPTIC LINK COMPONENTS

- **BULKHEAD FEEDTHROUGH**



BULKHEAD FEEDTHROUGH OR PANEL MOUNTING OF HFBR-45XX CONNECTORS



IN-LINE SPLICE FOR PLASTIC FIBER OPTIC CABLE

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Storage Temperature	T_S	-40	+75	°C	
Operating Temperature	T_A	0	+70	°C	
Nut Torque HFBR-4505/4515	T_N		0.7 100	N-m OzF-IN	1

Notes:
1. Recommended nut torque is $\frac{0.57}{80}$ $\frac{\text{N-m}}{\text{OzF-IN}}$

Mechanical/Optical Characteristics 0° to 70° C Unless Otherwise Specified.

Typical Data at 25° C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Note
Retention Force Connector/Module HFBR-4501/4511 to HFBR-15XX/25XX	F_{RC}		6.8		N	
Tensile Force Connector/Cable	F_T		22		N	
HFBR-4505/4515 Conn. to Conn. Loss	α_{CC}	0.7	1.5	2.8	dB	2, 3
Retention Force Connector/ Bulkhead HFBR-4501/4511 to HFBR-4505/4515	F_{RB}		7.8		N	

Notes:

2. Factory polish or field polish per recommended procedure.
3. Module to connector insertion loss is factored into the transmitter output optical power and the receiver input optical power level specifications.

Note:

For applications where frequent temperature cycling over extremes is expected please contact Hewlett-Packard for alternate connectoring techniques.

Cable Terminations

The following easy procedure describes how to make cable terminations. It is ideal for both field and factory installaiton. If a high volume connectoring technique is required please contact your Hewlett-Packard sales engineer for the recommended procedure and equipment.

Connectoring the cable is accomplished with the Hewlett-Packard HFBR-4595 Polishing Kit consisting of a Polishing Fixture and 600 grit abrasive paper and 3 micron pink lapping film (3M Company, OC3-14). No adhesive material is needed to secure the cable in the connector, and the connector can be used immediately after polishing.

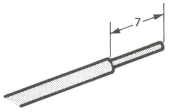
Connectors may be easily installed on the cable ends with readily available tools. Materials needed for the terminating procedure are:

1) Plastic Fiber Optic Cable
2) HFBR-4595 Polishing Kit
3) HFBR-4501 Gray Connector and Crimp Ring
4) HFBR-4511 Blue Connector and Crimp Ring
5) Industrial razor blade or wire cutters
6) 16 gauge latching wire strippers
7) Crimp Tool, AMP 90364-2

Step 1

The zip cord structure of the duplex cable permits easy separation of the channels. The channels should be separated approximately 50 mm (2.0 in.) back from the ends to permit connecting and polishing.

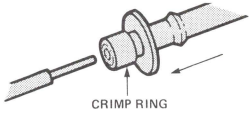
After cutting the cable to the desired length, strip off approximately 7 mm (0.3 in) of the outer jacket with the 16 gauge wire strippers. Excess webbing on duplex cable may have to be trimmed to allow the connector to slide over the cable.



Step 2

Place the crimp ring and connector over the end of the cable; the fiber should protrude about 3 mm (0.12 in.) through the end of the connector. Carefully position the ring so that it is entirely on the connector and then crimp the ring in place with the crimping tool.

Note: *Place the gray connector on the cable end to be connected to the transmitter and the blue connector on the cable end to be connected to the receiver to maintain the color coding (both connectors are the same mechanically).*



Step 3

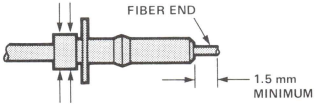
Any excess fiber protruding from the connector end may be cut off; however, the trimmed fiber should extend at least 1.5 mm (0.06 in.) from the connector end.

Insert the connector fully into the polishing fixture with the connector end protruding from the bottom of the fixture.

For high volume connectoring use the hardened steel HFBR-4596 polishing fixture.

Note: *The four dots on the bottom of the polishing fixture are wear indicators. Replace the polishing fixture when any dot is no longer visible.*

Place the 600 grit abrasive paper on a flat smooth surface. Pressing down on the connector, polish the fiber and the connector until the connector is flush with the end of the polishing fixture. Wipe the connector and fixture with a clean cloth or tissue.

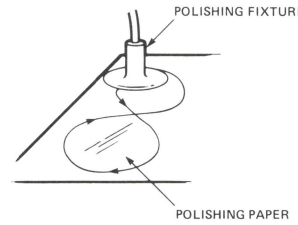


Step 4

Place the flush connector and polishing fixture on the dull side of the 3 micron pink lapping film and continue to polish the fiber and connector for approximately 25 strokes. The fiber end should be flat, smooth and clean.

The cable can now be used.

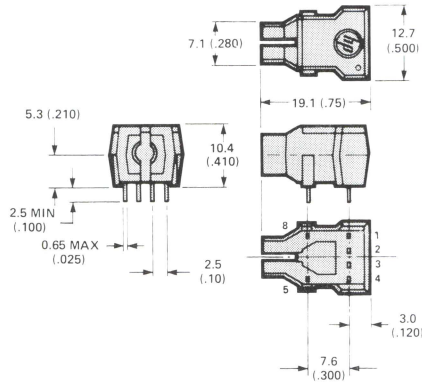
Note: *Use of the pink lapping film fine polishing step results in approximately a 2 dB improvement in coupling performance of either a transmitter-receiver link or a bulkhead/splice over 600 grit polish alone. This polish is comparable to Hewlett-Packard's factory polish. The fine polishing step may be omitted where an extra 2 dB of optical power is not essential as with short link lengths.*



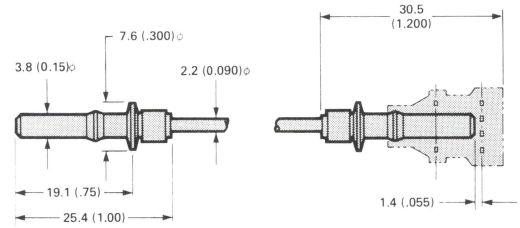
Mechanical Dimensions

All dimensions in mm (inches).
All dimensions ±0.25 mm unless otherwise specified.

HFBR-15XX (GRAY OR BLACK)/250X (BLUE) MODULE

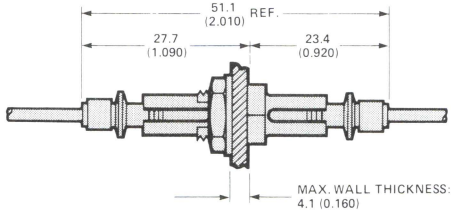


HFBR-4501 (GRAY)/4511 (BLUE) CONNECTOR

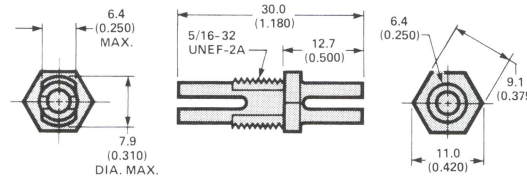


CONNECTORS DIFFER ONLY IN COLOR

BULKHEAD FEEDTHROUGH WITH TWO HFBR-4501/4511 CONNECTORS

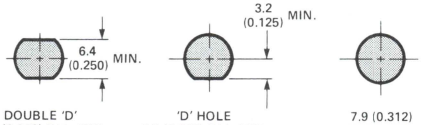


HFBR-4505 (GRAY)/4515 (BLUE) BULKHEAD FEEDTHROUGH



BULKHEAD FEEDTHROUGHS DIFFER ONLY IN COLOR

PANEL MOUNTING



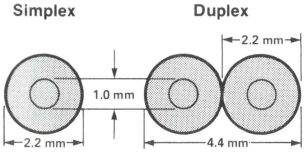
DOUBLE 'D'
7.9 (0.312) DIA. MIN.

'D' HOLE
7.9 (0.312) DIA. MIN.

7.9 (0.312)
HOLE MIN.

DIMENSIONS IN mm (INCHES)
ALL DIMENSIONS ±0.2 mm UNLESS NOTED.

FIBER OPTIC CABLE CONSTRUCTION



HEWLETT PACKARD

MINIATURE FIBER OPTIC LOGIC LINK

HFBR-1202
HFBR-2202
HFBR-4202

Features

- DC TO 5 MBAUD DATA RATE
- MAXIMUM LINK LENGTH
  625 Metres (Guaranteed)
  1600 Metres (Typical)
- TTL/CMOS COMPATIBLE OUTPUT
- MINIATURE, RUGGED METAL PACKAGE
- SINGLE +5V RECEIVER POWER SUPPLY
- INTERNALLY SHIELDED RECEIVER FOR EMI/RFI IMMUNITY
- PCB AND PANEL MOUNTABLE
- LOW POWER CONSUMPTION

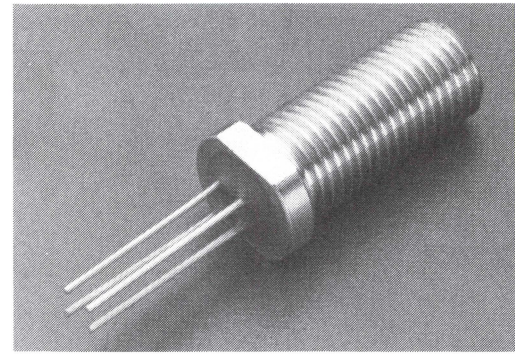
Applications

- EMC REGULATED SYSTEMS (FCC, VDE)
- EXPLOSION PROOF SYSTEMS IN OIL INDUSTRY/CHEMICAL PROCESS CONTROL INDUSTRY
- SECURE DATA COMMUNICATIONS
- WEIGHT SENSITIVE SYSTEMS (e.g. Avionics, Mobile Stations)
- HIGH VOLTAGE ISOLATION IN POWER GENERATION

Description

The HFBR-1202 Transmitter and HFBR-2202 Receiver are SMA style connector compatible fiber optic link components. Distances to 1600 metres at data rates up to 5 MBaud are achievable with these components.

The HFBR-1202 Transmitter contains a high efficiency GaAlAs emitter operating at 820 nm. Consistent coupling efficiency is assured by factory alignment of the LED with the optical axis of the package. Power coupled into the fiber varies less that 4 dB from part to part at a given temperature and drive current. The benefit of this is reduced dynamic range requirements on the receiver.

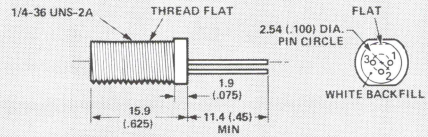


The HFBR-2202 Receiver incorporates a photo IC containing a photodetector and dc amplifier. An open collector Schottky transistor on the IC provides logic compatibility. The combination of an internal EMI shield, the metal package and an isolated case ground provides excellent immunity to EMI/RFI. For unusually severe EMI/ESD environments, a snap-on metal shield is available. The receiver is easily identified by the black epoxy backfill.

The HFBR-1202 Transmitter and HFBR-2202 Receiver are compatible with SMA style connectors, types A and B (see Figure 11.

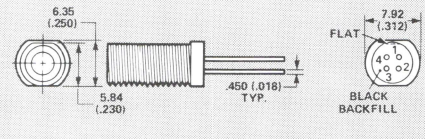
Mechanical Dimensions

HFBR-1202 TRANSMITTER



PIN	FUNCTION
1	ANODE
2	CATHODE
3	CASE

HFBR-2202 RECEIVER



PIN	FUNCTION
1	CASE
2	V_{CC}
3	DATA
4	COMMON

DIMENSIONS IN MILLIMETRES (INCHES)
UNLESS OTHERWISE SPECIFIED, THE TOLERANCES ARE:
.X ± .51 mm (.XX ± .02 IN)
.XX ± .13 mm (.XXX ± .005 IN)

System Design Considerations

The Miniature Fiber Optic Logic Link is guaranteed to work over the entire range of 0 to 625 metres at a data rate of dc -5 MBd, with arbitrary data format and typically less than 25% pulse width distortion, if the Transmitter is driven with I_F = 40 mA, R_1 = 82Ω. If it is desired to economize on power or achieve lower pulse distortion, then a lower drive current (I_F) may be used. The following example will illustrate the technique for optimizing I_F.

EXAMPLE: Maximum distance required = 250 metres. From Figure 2 the worst case drive current = 20 mA. From the Transmitter data — V_F = 1.8V (max.).

$$R_1 = \frac{V_{CC} - V_F}{I_F} = \frac{5 - 1.8V}{20\ mA} = 160\Omega$$

The optical power margin between the typical and worst case curves (Figure 2) at 250 metres is 4 dB. To calculate the worst case pulse width distortion at 250 metres, see Figure 8. The power into the Receiver is P_{RL} + 4 dB = -20 dBm. Therefore, the typical distortion is 40 ns or 20% at 5 MBd.

CABLE SELECTION

The link performance specifications on the following page are based on using cables that contain glass-clad silica fibers with a 100 μm core diameter and 140 μm cladding diameter. This fiber type is now a user accepted standard for local data communications links (RS-458, Class I, Type B). The HFBR-1202 Transmitter and HFBR-2202 Receiver are optimized for use with the 100/140 μm fiber. There is, however, no fundamental restriction against using other fiber types. Before selecting an alternate fiber type, several parameter need to be carefully evaluated.

will significantly affect the optical power coupled into the fiber are as follows:

a. **Fiber Core Diameter.** As the core diameter is increased, the optical power coupled increases, leveling off at about 250 μm diameter.
b. **Numerical Aperture (NA).** As the NA is increased, the optical power coupled increases, leveling off at an NA of about 0.34.
c. **Index Profile (α).** The Index profile parameter of fibers varies from 2 (fully graded index) to infinite (step index). Some gains in coupled optical power can be achieved at the expense of bandwidth, when α is increased.

In addition to the optical parameters, the environmental performance of the selected fiber/cable must be evaluated. Finally, the ease of installing connectors on the selected fiber/cable must be considered. Given the large number of parameters that must be evaluated when using a non-standard fiber, it is recommended that the 100/140 μm fiber be used unless unusual circumstances warrant the use of an alternate fiber/cable type.

SMA STYLE CONNECTORS

The HFBR-1202/2202 is compatible with either the Type A or Type B SMA style fiber optic connector (see Figure 11). The basic difference between the two connectors is the plastic half-sleeve on the stepped ferrule tip of the Type B connector. This step provides the capability to use a full length plastic sleeve to ensure good alignment of two connectors for an inline splice. Hewlett-Packard offers connectored cable that utilizes the Type A connector system because of the inherent environmental advantages of metal-to-metal interfaces.

Typical Circuit Configuration

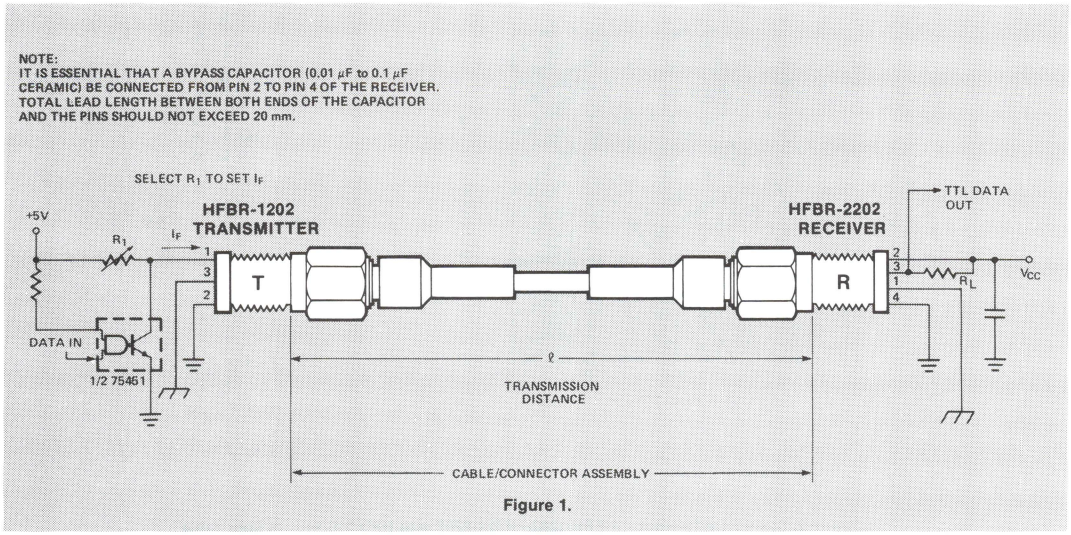


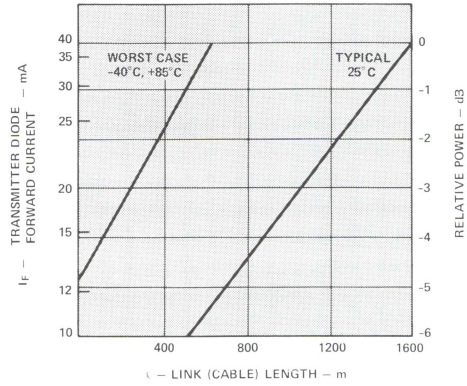
Figure 1.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Reference
TRANSMITTER					
Ambient Temperature	T_A	-40	+85	°C	
Peak Forward Input Current	$I_{F,PK}$		40	mA	Note 7
Average Forward Input Current	I_{FAV}		40	mA	Note 7
RECEIVER					
Ambient Temperature	T_A	-40	+85	°C	
Supply Voltage	V_{CC}	4.75	5.25	V	
Fan Out (TTL)	N		5		Note 3, Fig. 1
CABLE (see SMA connectored cable data sheet)					

System Performance -40° C to +85° C unless otherwise specified

Parameter	Symbol	Min.[1]	Typ.	Max.	Units	Conditions	Reference
Transmission Distance	ℓ	625	1600		Metres		Fig. 2, Note 9
Data Rate Synchronous		dc		5	MBaud		Note 10
Asynchronous		dc		2.5	MBaud		Note 10, Fig. 8
Propagation Delay LOW to HIGH	t_{PLH}		82		nsec	T_A = 25° C, P_R = -21 dBm $I_{F,PK}$ = 15 mA ℓ = 1 metre	Fig. 7, 8, 9
Propagation Delay HIGH to LOW	t_{PHL}		55		nsec		
System Pulse Width Distortion	t_D		27		nsec		
Bit Error Rate	BER			10^{-9}		Data Rate ≤5 MBaud P_R > -24 dBm (4 μW)	



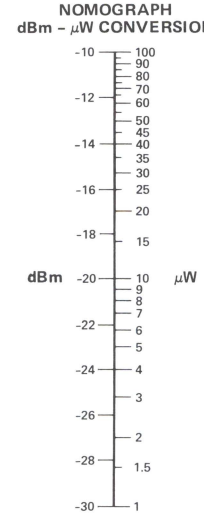
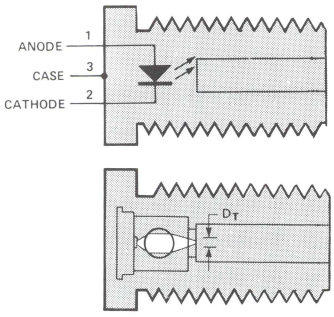


Figure 2. System Performance: HFBR-1202/HFBR-2202 with HP's 100/140 μm fiber cable

HFBR-1202 TRANSMITTER

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Unit	Reference
Storage Temperature		T_S	-55	+85	°C	
Operating Temperature		T_A	-40	+85	°C	Note 13
Lead Soldering Cycle	Temp.			+260	°C	Note 2
	Time			10	sec	
Forward Input Current	Peak	$I_{F,PK}$		40	mA	Note 7
	Average	$I_{F,AV}$		40	mA	
Reverse Input Voltage		V_R		2.5	V	



Electrical/Optical Characteristics -40° C to +85° C unless otherwise specified

Parameter	Symbol	Min.	Typ.[1]	Max.	Units	Conditions	Reference
Forward Voltage	V_F		1.5	1.8	V	I_F = 40 mA	Figure 5
Forward Voltage Temperature Coefficient	$\Delta V_F/\Delta T$		-0.91		mV/° C	I_F = 40 mA	Figure 5
Reverse Breakdown Voltage	V_{BR}	2.5	4.0		V	I_R = 100 μA	
Numerical Aperture	NA		.34				
Optical Port Diameter	D_T		250		μm		Note 11
Peak Emission Wavelength	λ_P		820		nm		Figure 6
Peak Output Optical Power Coupled into HFBR-3000 Fiber Cable/Connector Assembly, 100/140 μm	P_T	-17	-16	-13	dBm	I_F = 40 mA	Figure 3
		20	25	50	μW	T_A = 25° C	Notes 4, 15
		-18		-12.3	dBm	I_F = 40 mA	
		15.8		59	μW	-40° C < T_A < 85° C	
Output Optical Power Coupled into 50/125 μm Fiber	P_T		-24		dBm	I_F = 40 mA	Figure 3
			4		μW	T_A = 25° C	Notes 14, 15
Output Optical Power Coupled into Siecor 100/140 μm Fiber Cable or Equivalent	P_T		-18		dBm	I_F = 40 mA T_A = 25° C	Figure 3 Notes 15, 16
Optical Power Temperature Coefficient	$\Delta P_T/\Delta T$		-.017		dB/° C		Figure 4

Dynamic Characteristics -40° C to +85° C unless otherwise specified

Parameter	Symbol	Min.	Typ.[1]	Max.	Units	Conditions	Reference
Propagation Delay LOW to HIGH	t_{PLH}		17		nsec	$I_{F,PK}$ = 10 mA	Note 8 Figure 7
Propagation Delay HIGH to LOW	t_{PHL}		6		nsec		

Notes:

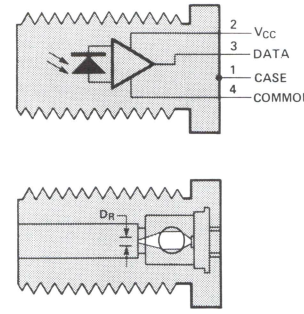
1. Typical data at T_A = 25° C, V_{CC} = 5.0V dc.
2. 2.0 mm from where leads enter case.
3. 8 mA load (5 x 1.6 mA). R_L = 560Ω.
4. Measured at the end of 1.0 metre HP's 100/140 μm Fiber Optic Cable with large area detector and cladding modes stripped, terminated with the appropriate type of connector. This assembly approximates a Standard Test Fiber. The fiber NA is 0.28, measured at the end of greater than 300 metres length of fiber, the NA being defined as the sine of the half angle determined by the 10% intensity points.
5. Measured at the end of HP's 100/140 μm Fiber Optic Cable with large area detector.
6. When changing microwatts to dBm, the optical flux is referenced to one milliwatt (1000 μW).
   Optical Flux, P (dBm) = $10 \log \frac{P(\mu W)}{1000\ \mu W}$
7. I_{FPK} should not be less than 10 mA in the "ON" state. This is to avoid the long turn-on time that occurs at low input current. I_{FAV} may be arbitrarily low, as there is no duty factor restriction.

WARNING: OBSERVING THE TRANSMITTER OUTPUT POWER UNDER MAGNIFICATION MAY CAUSE INJURY TO THE EYE. When viewed with the unaided eye, the infrared output is radiologically safe; however, when viewed under magnification, precaution should be taken to avoid exceeding the limits recommended in ANSI Z136.1-1981.

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Reference
Storage Temperature		T_S	-55	+85	°C	
Operating Temperature		T_A	-40	+85	°C	
Lead Soldering Cycle	Temp.			+260	°C	Note 2
	Time			10	sec	
Supply Voltage		V_{CC}	-0.5	+7.0	V	
Output Current		I_O		25	mA	
Output Voltage		V_O	-0.5	+18.0	V	
Output Collector Power Dissipation		$P_{O,AV}$		40	mW	

HFBR/2202 RECEIVER



Electrical/Optical Characteristics

-40° C to +85° C and 4.75 ≤ V_{CC} ≤ 5.25 V unless otherwise specified.

Parameter	Symbol	Min.	Typ.[11]	Max.	Units	Conditions	Reference
High Level Output Current	I_{OH}		5	250	μA	V_O = 18V P_R < -40 dBm	
Low Level Output Voltage	V_{OL}		0.4	0.5	V	I_O = 8 mA P_R > -24 dBm	
High Level Supply Current	I_{CCH}		3.5	6.3	mA	V_{CC} = 5.25 V P_R < -40 dBm	
Low Level Supply Current	I_{CCL}		6.2	10	mA	V_{CC} = 5.25 V P_R > -24 dBm	
Optical Port Diameter	D_R		700		μm		Note 12
Numerical Aperture	NA		.32				

Dynamic Characteristics

-40° C to +85° C and 4.75 ≤ V_{CC} ≤ 5.25 V unless otherwise specified.

Parameter	Symbol	Min.	Typ.[11]	Max.	Units	Conditions	Reference
Input Power Level Logic HIGH	P_{RH}			-40 0.1	dBm μW	λP = 820 nm	Note 5
Input Power Level Logic LOW	P_{RL}	-25.4		-11.2	dBm	T_A= +25° C	Fig. 4, Note 5
		2.9		76	μW		
		-24		-12.0	dBm	-40 < T_A < 85° C	
		4.0		63	μW		
Propagation Delay LOW to HIGH	t_{PLHR}		65		nsec	T_A = 25° C, P_R = -21 dBm	Note 8, Fig. 7
Propagation Delay HIGH to LOW	t_{PHLR}		49		nsec		

Notes:

8. Propagation delay through the system is the result of several sequentially-occurring phenomena. Consequently it is a combination of data-rate-limiting effects and of transmission-time effects. Because of this, the data-rate limit of the system must be described in terms of time differentials between delays imposed on falling and rising edges.

   As the cable length is increased, the propagation delays increase at 5 ns per metre of length increase. Data rate, as limited by pulse width distortion, is not affected by increasing cable length if the optical power level at the Receiver is maintained.
9. Worst case system performance is based on worst case performance of individual components: transmitter at +85° C, receiver at -40° C and cable at- 20° C.
10. Synchronous data rate limit is based on these assumptions: (a) 50% duty factor modulation, e.g. Manchester I or BiPhase (Manchester II); (b) continuous data; (c) PLL (Phase Lock Loop) demodulation; (d) TTL threshold.

    Asynchronous data rate limit is based on these assumptions: (a) NRZ data; (b) arbitrary timing — no duty factor restriction; (c) TTL threshold.

    The EYE pattern describes the timing range within which there is no uncertainty of the logic state, relative to a specific threshold, due to either noise or intersymbol (prop. delay) effects.
11. D_T is measured at the plane of the fiber face and defines a diameter where the optical power density is within 10 dB of its maximum.
12. D_R is the effective diameter of the detector image on the plane of the fiber face. The numerical value is the product of the actual detector diameter and the lens magnification.
13. HP's 100/140 μm Fiber Cable is specified at a narrower temperature range, -20° C to 85° C.
14. Measured at the end of 1.0 metre 50/125 μm fiber with large area detector and cladding modes stripped, approximating a Standard Test Fiber. The fiber NA is 0.21, measured at the end of a 2.0 metre length, the NA being defined as the sine of the half angle determined by the 5% of peak intensity points.
15. Output Optical Power into connectored fiber cable other than HP's Fiber Optic Cable/Connector Assemblies may be different than specified because of mechanical tolerances of the connector, quality of the fiber surface, and other variables.
16. Measured at the end of 1.0 metre Siecor 100/140 μm fiber cable or equivalent, with large area detector and cladding modes stripped, terminated with the appropriate type of connector. This assembly approximates a Standard Test Fiber. The fiber NA is 0.275, measured at the end of a 2.0 metre length, the NA being defined as the sine of the half angle determined by the 5% of peak intensity points.

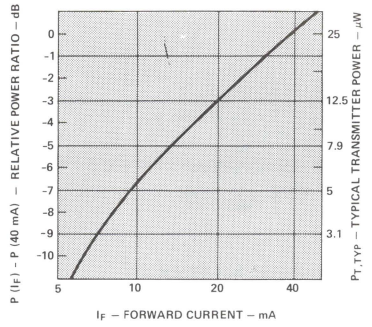


Figure 3. Normalized Transmitter Output vs. Forward Current

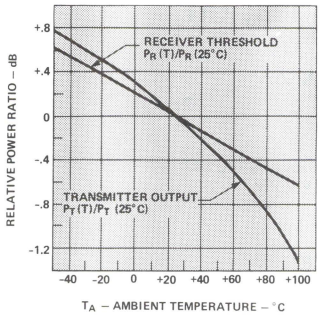


Figure 4. Normalized Thermal Effects in Transmitter Output, Receiver Threshold, and Link Performance (Relative Threshold)

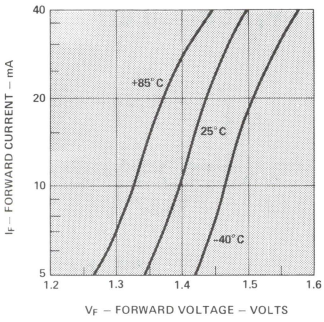


Figure 5. Forward Voltage and Current Characteristics for the Transmitter LED.

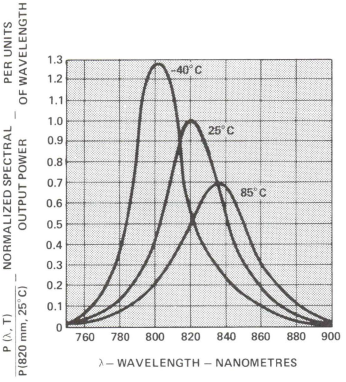


Figure 6. Transmitter Spectrum Normalized to the Peak at 25° C

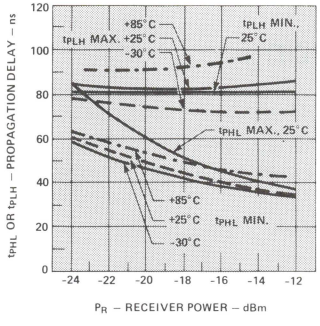


Figure 7. Propagation Delay through System with One Metre of Cable

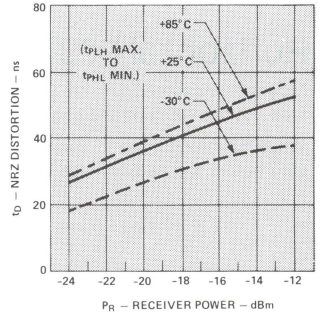
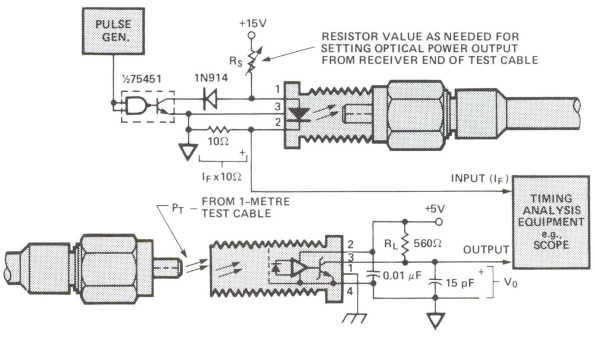


Figure 8. Worst-Case Distortion of NRZ EYE-pattern with Pseudo Random Data at 5 Mb/s. (see note 10)



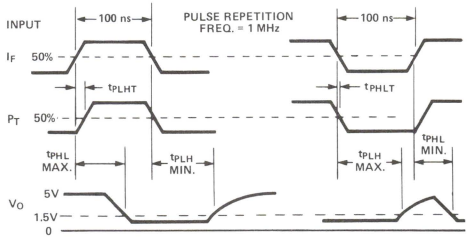
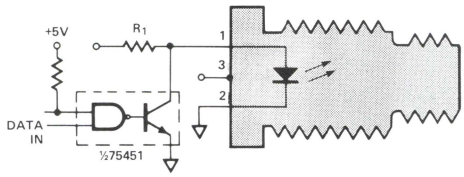
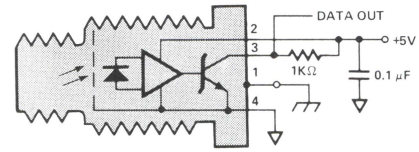


Figure 9. System Propagation Delay Test Circuit and Waveform Timing Definitions

Typical Circuit Configuration



HFBR-1201 TRANSMITTER



HFBR-2201 RECEIVER

Good system performance requires clean port optics and cable ferrules to avoid obstructing the optical path. Clean compressed air often is sufficient to remove particles of dirt; methanol or Freon™ on a cotton swab also works well.

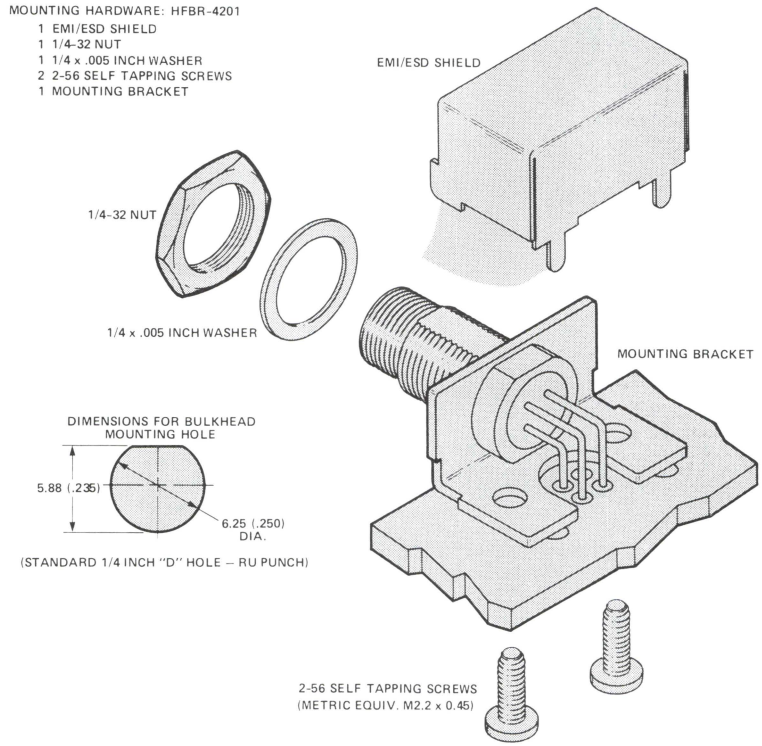
It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from pin 2 to pin 4 of the receiver. Total lead length between both ends of the capacitor and the pins should not exceed 20 mm.

Horizontal PCB Mounting

Mounting at the edge of a printed circuit board with the lock nut overhanging the edge is recommended.

When bending the leads, avoid sharp bends right where the lead enters the backfill. Use needle nose pliers to support the leads at the base of the package and bend the leads as desired.

When soldering, it is advisable to leave the protective cap on the unit to keep the optics clean.



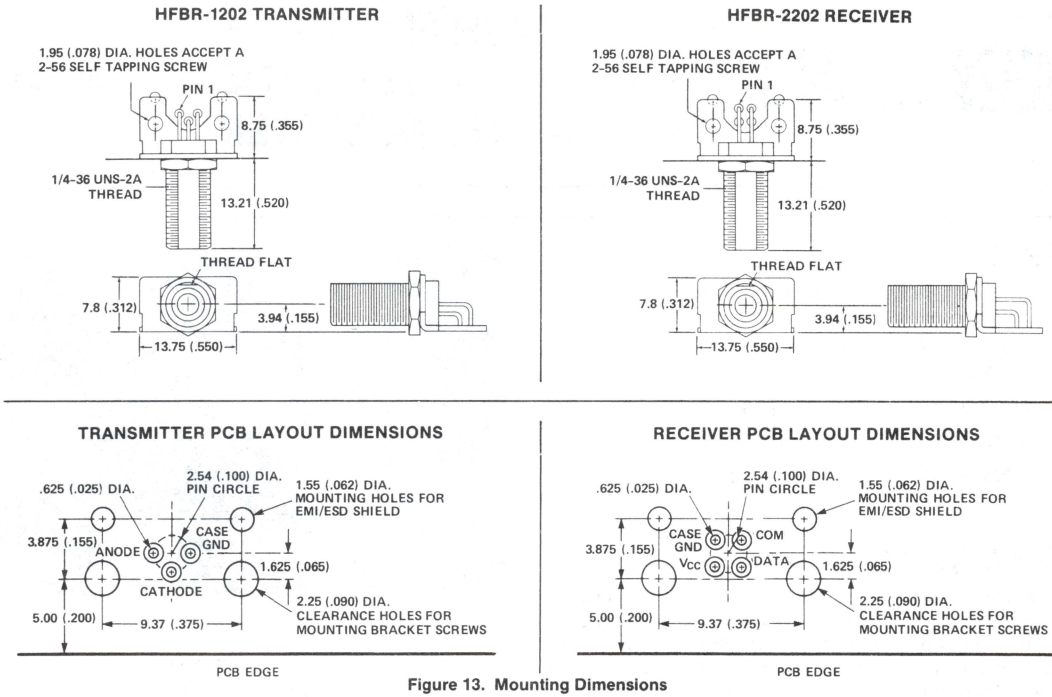


Figure 13. Mounting Dimensions

DIMENSIONS IN MILLIMETRES (INCHES).

Ordering Guide

Transmitter: HFBR-1202 (SMA Connector Compatible)

Receiver: HFBR-2202 (SMA Connector Compatible)

Mounting Hardware: HFBR-4202 (SMA Connector Compatible)

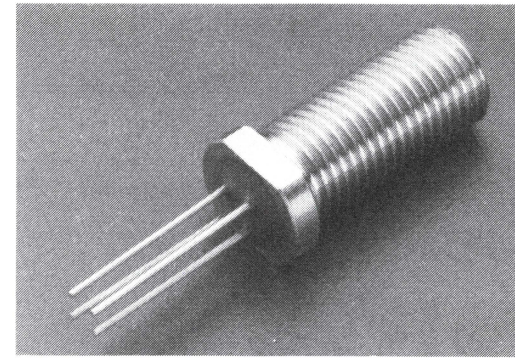
HEWLETT PACKARD

HIGH EFFICIENCY FIBER OPTIC TRANSMITTER

HFBR-1204

Features

- **OPTICAL POWER COUPLED INTO 100/140 μm FIBER CABLE**
  - **—9.8 dBm Guaranteed at 25° C**
  - **—7.4 dBm Typical**
- **FACTORY ALIGNED OPTICS**
- **RUGGED MINIATURE PACKAGE**
- **COMPATIBLE WITH SMA CONNECTORS**



Description

The HFBR-1204 Fiber Optic Transmitter contains an etched-well 820 nm GaAlAs emitter capable of coupling greater than -10 dBm of optical power into HP's 100/140 μm SMA connectored cable assemblies. This high power level is useful for fiber lengths greater than 1 km, or systems where star couplers, taps, or in-line connectors create large fixed losses.

Consistent coupling efficiency is assured by factory alignment of the LED with the mechanical axis of the package connector port. Power coupled into the fiber varies less than 5 dB from part to part at a given drive current and temperature. The benefit of this is reduced dynamic range requirements on the receiver.

High coupling efficiency allows the emitters to be driven at low current levels resulting in low power consumption and increased reliability of the transmitter. Another advantage of the high coupling efficiency is that a significant amount of power can still be launched into smaller fiber such as 50/125 μm (-19.1 dBm typ.).

The HFBR-1204 transmitter is housed in a rugged miniature package. The lens is suspended to avoid mechanical contact with the active devices. This assures improved reliability by eliminating mechanical stress on the die due to the lens. For increased ESD protection and design flexibility, both the anode and cathode are insulated from the case.

HFBR-1204 is compatible with SMA style connectors. The low profile package is designed for direct mounting on printed circuit boards or through panels without additional heat sinking. A complete mounting hardware package (HFBR-4202) is available for horizontal mounting on PCBs, including a snap-on metal shield for harsh EMI/ESD environments.

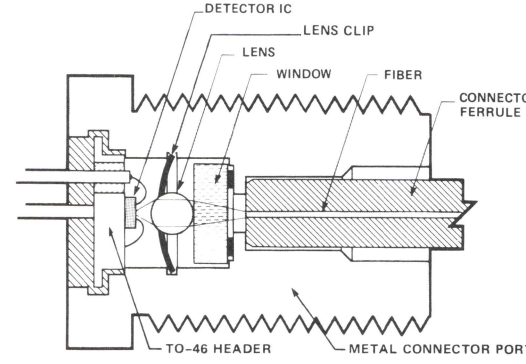
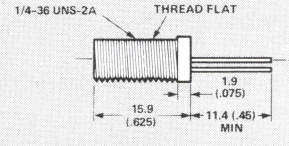
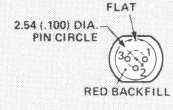


Figure 1. Cross Sectional View

Mechanical Dimensions

HFBR-1204





PIN	FUNCTION
1	ANODE
2	CATHODE
3	CASE

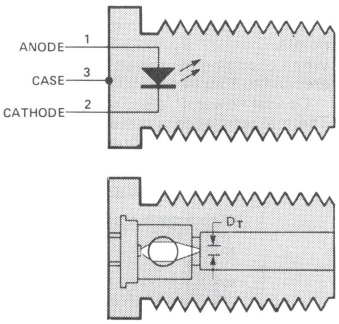
DIMENSIONS IN MILLIMETRES (INCHES)

HFBR-1204 TRANSMITTER

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Unit	Reference
Storage Temperature		T_S	-55	+85	°C	
Operating Temperature		T_A	-40	+85	°C	Note 4
Lead Soldering Cycle	Temp.			+260	°C	Note 1
	Time			10	sec	
Forward Input Current	Peak	$I_{F,PK}$		100	mA	
	Average	$I_{F,AV}$		100	mA	
Reverse Input Voltage		V_R		1.0	V	
Voltage, Case-to-Junction		V_C		25	V	

HFBR-1204 TRANSMITTER



Electrical/Optical Characteristics -40° C to +85° C unless otherwise specified

Parameter	Symbol	Min.	Typ.[2]	Max.	Units	Conditions	Reference
Forward Voltage	V_F	1.44	1.72	1.94	V	I_F = 100 mA	Figure 2
Forward Voltage Temperature Coefficient	$\Delta V_F/\Delta T$		-0.54		mV/° C	I_F = 100 mA	Figure 2
Reverse Breakdown Voltage	V_{BR}	1.0	3.1		V	I_R = 100 μA	
Numerical Aperture	NA		0.38				
Optical Port Diameter	D_T		250		μm		Note 3
Peak Emission Wavelength	λ_P		820		nm		Figure 5
Peak Output Optical Power Coupled into HP's 100/140 μm SMA Connectored Cable	P_T	-9.8	-7.4	-5.0	dBm	I_F = 100 mA	Figure 3, 4
		105	182	316	μW	T_A = 25° C	Notes 4, 5,
		-11.2		-4.2	dBm	I_F = 100 mA	6, 8
		76		380	μW	-40° C < T_A < 85° C	
Output Optical Power Coupled into 50/125 μm Fiber	P_T		-19.1		dBm	I_F = 100 mA	Figure 3, 4
			12		μW	T_A = 25° C	Notes 5, 7
Output Optical Power Coupled into Siecor 100/140 μm Fiber Cable or Equivalent	P_T		-9.4		dBm	I_F = 100 mA T_A = 25° C	Figure 3, 4 Notes 5, 11
Optical Power Temperature Coefficient	$\Delta P_T/\Delta T$		-.014		dB/° C	I_F = 100 mA	Figure 3
Case Isolation Resistance (Case to Pins 1 or 2)	R_{CASE}	1			MΩ	V_{CASE} = 25 V	
Thermal Resistance	Θ_{JC}		90		°C/W		Note 9
Rise Time, Fall Time (10 to 90%)	t_r, t_f		11		nsec		Figure 6 Note 10

WARNING: OBSERVING THE TRANSMITTER OUTPUT POWER UNDER MAGNIFICATION MAY CAUSE INJURY TO THE EYE. When viewed with the unaided eye, the infrared output is radiologically safe; however, when viewed under magnification, precaution should be taken to avoid exceeding the limits recommended in ANSI Z136.1-1981.

Notes:

1. 2.0 mm from where leads enter case.
2. Typical data at T_A = 25° C.
3. D_T is measured at the plane of the fiber face and defines a diameter where the optical power density is within 10 dB of the maximum.
4. HP's 100/140 μm fiber cable specified at a narrower temperature range, -20° C to 85° C.
5. Output Optical Power into connectored fiber cable other than HP's Cable/Connector Assemblies may be different than specified because of mechanical tolerances of the connector, quality of the fiber surface and other variables.
6. Measured at the end of 1.0 metre of HP's 100/140 μm Fiber Optic Cable with large area detector and cladding modes stripped, terminated with the appropriate type of connector. This assembly approximates a Standard Test Fiber. The fiber NA is 0.28, measured at the end of greater than 300 metres length of fiber, the NA being defined as the sine of the half angle determined by the 5% intensity points.

7. Measured at the end of 1.0 metre 50/125 μm fiber with large area detector and cladding modes stripped, approximating a Standard Test Fiber. The fiber NA is 0.21, measured at the end of a 2.0 metre length, the NA being defined as the sine of the half angle determined by the 5% of peak intensity points.
8. When changing microwatts to dBm, the optical power is referenced to 1 milliwatt (1000 μW).
   Optical Power, P (dBm) = 10 log P (μW)/1000 μW
9. Thermal resistance is measured with the transmitter coupled to a connector assembly and mounted on a printed circuit board with the HFBR-4202 mounting hardware.
10. Measured with a 1 mA pre-bias current and terminated into a 50 ohm load.
11. Measured at the end of 1.0 metre Siecor 100/140 μm fiber cable or equivalent, with large area detector and cladding modes stripped, terminated with the appropriate type of connector. This assembly approximates a Standard Test Fiber. The fiber NA is 0.275, measured at the end of a 2.0 metre length, the NA being defined as the sine of the half angle determined by the 5% of peak intensity points.

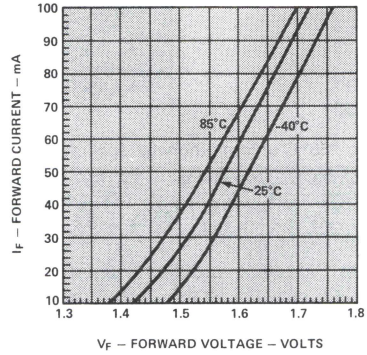


Figure 2. Forward Voltage and Current Characteristics

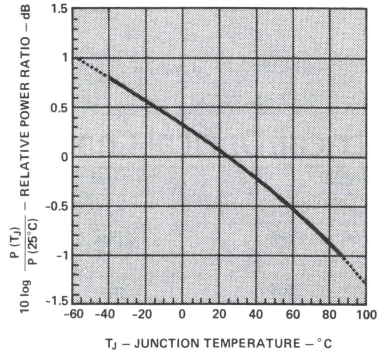


Figure 3. Normalized Thermal Effects in Transmitter Output

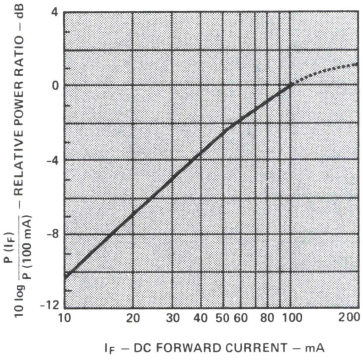


Figure 4. Normalized Transmitter Output vs. DC Forward Current

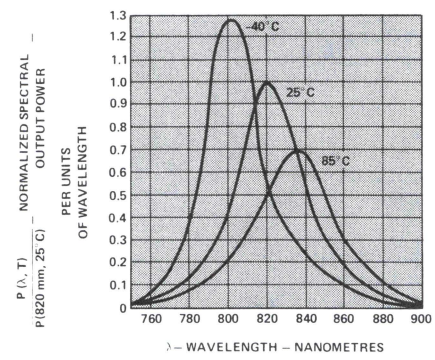


Figure 5. Transmitter Spectrum Normalized to the Peak at 25° C

Ordering Guide

Transmitter: HFBR-1204 (SMA Connector Compatible)

Receiver: HFBR-2202 (5 MBaud, SMA Connector)
HFBR-2204 (40 Mbaud, SMA Connector Compatible)

Mounting Hardware: HFBR-4202 (SMA Connector Compatible)

Fiber Optic Cable — see data sheets

High Speed Operation

Rise and fall times can be improved by using a pre-bias current and "speed-up" capacitor. A 1 mA pre-bias current will significantly reduce the junction capacitance and will couple less than −34 dBm of optical power into the fiber cable. The TTL compatible circuit in Figure 7 using a speed-up capacitor will provide typical rise and fall times of 10 ns.

$$I_{PEAK} = 100\ mA = \frac{V_{CC} - V_F}{34.9\Omega}$$

$$I_{AVG} = 78\ mA = \frac{V_{CC} - V_F}{34.9 + 10\Omega}$$

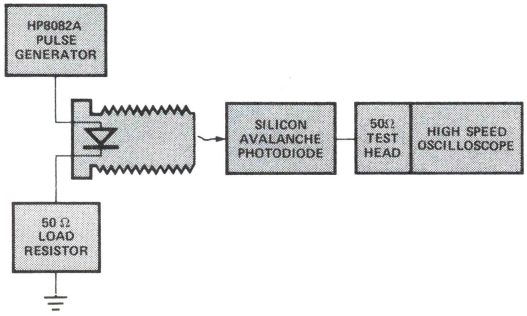


Figure 6. Test Circuit for Measuring t_r, t_f

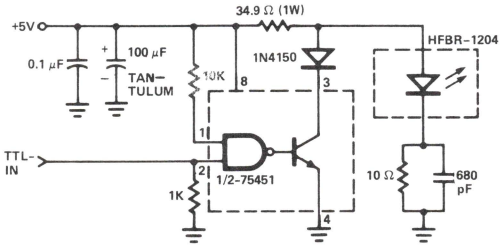


Figure 7. High Speed TTL Circuit

Link Design

With transmitter performance specified as power in dBm into a fiber of particular properties (core size, NA, and index profile), and receiver performance given in terms of the power in dBm radiated from the same kind of fiber, then the link design equation is simply:

(1) $P_T - \ell \cdot \alpha_O = P_R$

where

P_T = transmitter power into fiber (dBm)
ℓ = fiber (cable) length (km)
α_O = fiber attenuation (dB/km)
P_R = receiver power, from fiber, (dBm)

For transmitter input current in the range from 10 to 100 mA, the power varies approximately linearly:

(2) $P_T = P_O + 10 \log (I/I_O)$

where

P_O = transmitter power specification (dBm) at I_O
I_O = specified transmitter current (100 mA)
I = selected transmitter current (mA)

To allow for the dynamic range limits of proper receiver performance, it is necessary that a link with maximum transmitter power and minimum attenuation does not OVERDRIVE the receiver and that minimum transmitter power with maximum attenuation does not UNDERDRIVE it. These limits can be expressed in a combination of the two equations above:

(3) $P_{O\ MAX} + 10 \log (I_{MAX}/I_O) - \ell * \alpha_{OMIN} < P_{R\ MAX}$

(4) $P_{O\ MIN} + 10 \log (I_{MIN}/I_O) - \ell * \alpha_{OMAX} > P_{R\ MIN}$

where

$P_{O\ MAX}$, $P_{O\ MIN}$ = max., min. specified power from transmitter (dBm) at $I = I_O$
I_{MAX}, I_{MIN} = max., min. selected transmitter operating current (mA)
$P_{R\ MAX}$, $P_{R\ MIN}$ = max., min. specified power at receiver (dBm)
α_{OMAX}, α_{OMIN} = max., min. attenuation (dB/km)

A more useful form of these equations comes from solving them for the current ratio, expressed in dB:

(5) $10 \log (I_{MAX}/I_O) < P_{R\ MAX} - P_{O\ MAX} + \ell \cdot \alpha_{OMIN}$

(6) $10 \log (I_{MIN}/I_O) > P_{R\ MIN} - P_{O\ MIN} + \ell \cdot \alpha_{OMAX}$

These are plotted in Figure 8 as the OVERDRIVE LINE, and UNDERDRIVE LINE, respectively for the following components:

HFBR-1204 Transmitter $-11.2 < P_T < -4$ dBm
HFBR-2204 Receiver (25 MHz) $-28.5 < P_R < 12.6$ dBm
HFBR-2204 Receiver (2.5 MHz) $-35.5 < P_R < -12.6$ dBm
HP's 100/140 μm Fiber Cable $4 < \alpha_O < 8$ dB/km

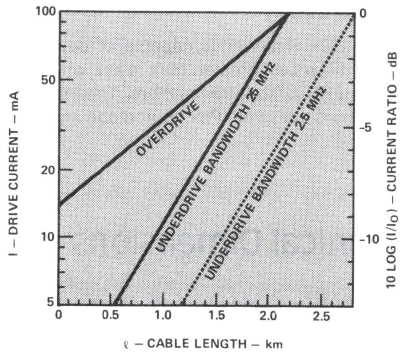


Figure 8. Link Design Limits.

These design equations take account only of the power loss due to attenuation. The specifications for the receiver and transmitter include loss effects in end connectors. If the system has other fixed losses, such as from directional couplers or additional in-line connectors, the effect is to shift both OVERDRIVE and UNDERDRIVE lines upward by the amount of the additional loss ratio.

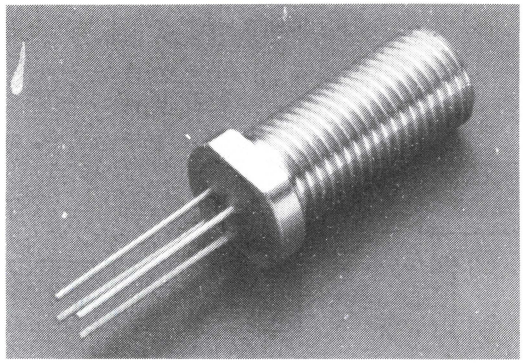
HEWLETT PACKARD

40 MBd MINIATURE FIBER OPTIC RECEIVER

HFBR-2204

Features

- DATA RATES UP TO 40 MBd
- HIGH OPTICAL COUPLING EFFICIENCY
- RUGGED, MINIATURE METAL PACKAGE
- COMPATIBLE WITH SMA STYLE CONNECTORS
- VERSATILE ANALOG RECEIVER OUTPUT
- 25 MHz ANALOG BANDWIDTH



Applications

- DATA ACQUISITION AND PROCESS CONTROL
- SECURE DATA COMMUNICATION
- EMC REGULATED SYSTEMS (FCC/VDE)
- EXPLOSION PROOF SYSTEMS
- WEIGHT SENSITIVE SYSTEMS (e.g., AVIONICS, MOBILE STATIONS)
- VIDEO TRANSMISSION

Description

The HFBR-2204 Receiver is capable of data rates up to 40 MBd at distances greater than 1 km when used with cable and HFBR-1202/4 Transmitters. The HFBR-2204 Receivers contains a discrete PIN photodiode and preamplifier IC.

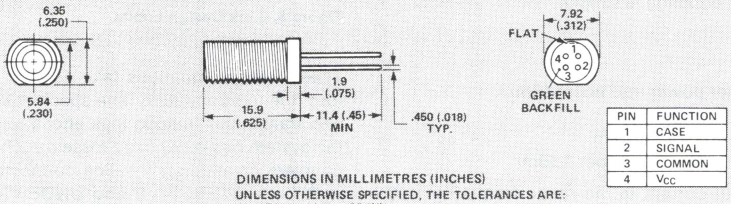
The signal from this simple analog receiver can be optimized for a variety of transmission requirements. For example, the circuits in Application Bulletin 73 add low-cost external components to achieve logic compatible signal levels optimized for various data formats and data rates.

Each of these fiber optic components uses the same rugged, lensed, miniature package. This package assures a consistent, efficient optical coupling between the active devices and the optical fiber.

The HFBR-2204 Receiver is compatible with SMA style connectors, types A and B (see Figure 11 and HP's 100/140 μm SMA connectored cable assemblies. HP's 100/140 μm fiber optic cable can be ordered with or without connectors.

Mechanical Dimensions

HFBR-2204 RECEIVER



PIN	FUNCTION
1	CASE
2	SIGNAL
3	COMMON
4	V_{CC}

DIMENSIONS IN MILLIMETRES (INCHES)
UNLESS OTHERWISE SPECIFIED, THE TOLERANCES ARE:
.X ± .51 mm (.XX ± .02 IN)
.XX ± .13 mm (.XXX ± .005 IN)

Electrical Description

The HFBR-2204 Fiber Optic Receiver contains a PIN photodiode and low noise transimpedance pre-amplifier hybrid circuit with an inverting output (see note 10). The HFBR-2204 receives an optical signal and converts it ot an analog voltage. The output is a buffered emitter-follower. Because the signal amplitude from the HFBR-2204 Receiver is much larger than from a simple PIN photodiode, it is less susceptible to EMI, especially at high signal rates.

The frequency response is typically dc to 25 MHz. Although the HFBR-2204 is an analog receiver, it is easily made compatible with digital systems (see Application Bulletin 73). Separate case and signal ground leads are provided for maximum design flexibility.

It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from Pin 4 (V_{CC}) to Pin 3 (circuit common) of the receiver. Total lead length between both ends of the capacitor and the pins should be less than 20 mm.

Mechanical Description

The HFBR-2204 Fiber Optic Receiver is housed in a miniature package intended for use with HP's 100/140 μm SMA connectored cable assemblies. This package has important performance advantages:

1. Precision mechanical design and assembly procedures assure the user of consistent high efficiency optical coupling.
2. The lens is suspended to avoid contact with the active devices, thereby assuring improved reliability.
3. The versatile miniature package is easy to mount. This low profile package is designed for direct mounting on printed circuit boards or through panels without additional heat sinking.

   A complete mounting hardware package is available for horizontal PCB applications, including a snap-on metal shield for harsh EMI/ESD environments.

   Good system performance requires clean port optics and cable ferrules to avoid obstructing the optical path. Clean compressed air often is sufficient to remove particles of dirt; Methanol or Freon on a cotton swab also works well.

   Note:
   When installing connectored cable on the optical port, do not use excessive force to tighten the nut. Finger tightening is sufficient to ensure connectoring integrity, while use of a wrench may cause damage to the connector or the optics.

System Design Considerations

For additional information, see Application Bulletin 73.

OPTICAL POWER BUDGETING

The HFBR-2204 Fiber Optic Receivers when used with the HFBR-1202 Fiber Optic Transmitter can be operated at a signalling rate of more than 40 MBd over a distance greater than 1000 metres (assuming 8 dB/km cable attenuation). For shorter transmission distances, power consumption can be reduced by decreasing Transmitter drive current. At a lower data rate, the transmission distance may be increased by applying bandwidth-filtering at the output of the HFBR-

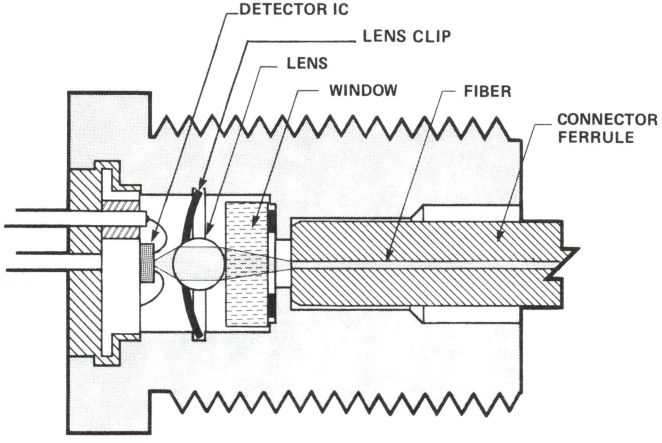


Figure 1. Cross Sectional View

2204 Receiver; since noise is reduced as the square root of the bandwidth, the sensitivity of the circuit is proportionately improved provided these two conditions are met:

a. input-referred noise of the follow on circuit is well below the filtered noise of the Receiver
b. logic comparator threshold is reduced in the same proportion as the noise reduction

As an example, consider a link with a maximum data rate of 10 MBd (e.g., 5 Mb/s Manchester); this requires a 3 dB bandwidth of only 5 MHz. For this example, the input-referred rms noise voltage of the follow-on circuit is 0.03 mV. The equivalent optical noise power of the complete receiver (P_{NO}) is given by:

$$P_{NO} = [(V_{NO})^2 (B/Bo) + (V_{NI})^2]^{0.5} / R_P$$

V_{NO} = rms output noise voltage of the HFBR-2203/04 with no bandwidth filtering
V_{NI} = input-referred rms noise voltage of the follow-on circuit
B = filtered 3 dB bandwidth
Bo = Unfiltered 3dB bandwidth of the HFBR-2203/04 (25 MHz)
R_P = optical-to-electrical responsivity (mV/μW) of the HFBR-2240

Note that noise adds in an rms fashion, and that the square of the rms noise voltage of the HFBR-2204 is reduced by the bandwidth ratio, B/Bo.

From the receiver data (Electrical/Optical Characteristics) taking worst-case values, and applying NO bandwidth filtering (B/Bo = 1):

$$P_{NO} = \frac{[(0.43)^2+(0.03)^2]^{0.5}\ \text{mV}}{4.6\ \text{mV}/\mu\text{W}} = 0.094\ \mu\text{W or } -40.3\ \text{dBm}$$

To ensure a bit error rate less than 10^{-9} requires the signal power to be 12 times larger (+11 dB) than the rms noise as referred to the Receiver input. The minimum Receiver input power is then:

$$P_{RMIN} = P_{NO} + 11\ \text{dB} = -29.3\ \text{dBm}$$

With the application of a 5 MHz low-pass filter, the bandwidth ratio becomes:

$$B/B_O = 5\ \text{MHz}/25\ \text{MHz} = 0.2$$

Note that 25 MHz should be used for the total noise bandwidth of the HFBR-2204. Inserting this value of the bandwidth ratio in the expressions for P_{NO} and P_{RMIN} above yields the results:

$$P_{NO} = 0.042\ \mu\text{W or } -43.8\ \text{dBm and } P_{RMIN} = -32.8\ \text{dBm}$$

Given the HFBR-1202 Transmitter optical power P_T = −18 dBm at I_F = 40 mA, and allowing a 3 dB margin, a minimum optical power budget of 11.8 dB is obtained:

$$[-18\ \text{dBm} - 3\ \text{dB} - (-32.8\ \text{dBm})] = 11.8\ \text{dB}$$

Using 8 dB/km optical fiber, this translates into a minimum link length of 1475 metres (typical link power budget for this configuration is approximately 17.2 dB or 3130 metres with 5.5 dB/km fiber).

BANDWIDTH

The bandwidth of the HFBR—2204 is typically 25 MHz. Over the entire temperature range of -40° C to +85° C, the rise and fall times vary in an approximately linear fashion with temperature. Under worst case conditions, t_r and t_f may reach a maximum of 26 ns, which translates to a 3 dB bandwidth of:

$$f_{3dB} \simeq \frac{350}{t_r} = \frac{350}{26\ \text{ns}} = 13.5\ \text{MHz}$$

The receiver response is essentially that of a single-pole system, rolling off at 6 dB/octave. In order for the receiver to operate up to 40 MBd even though its worst case 3 dB bandwidth is 13.5 MHz, the received optical power must be increased by 3 dB to compensate for the restricted receiver transmission bandwidth.

PRINTED CIRCUIT BOARD LAYOUT

When operating at data rates above 10 MBd, standard PC board precautions should be taken. Lead lengths greater than 20 mm should be avoided whenever possible and a ground plane should be used. Although transmission line techniques are not required, wire wrap and plug boards are not recommended.

OPERATION WITH HEWLETT-PACKARD TRANSMITTERS

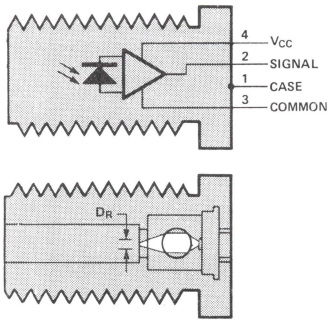
Hewlett-Packard offers two transmitters compatible with the HFBR-2204 Link performance with each transmitter is shown below for 25°C operation with HP's 100/140 μm glass fiber cable. See product data sheets for further information.

	HFBR-1202 -17 dBm Coupled Optical Power	HFBR-1204 -9.8 dBm Coupled Optical Power
HFBR-2204 -27 dBm Sensitivity	1200 m 40 MBd	2100 m 40 MBd
HFBR-2204 -32 dBm Sensitivity	1800 M 10 MBd	2800 M 10 MBd

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Unit	Reference
Storage Temperature		T_S	-55	85	°C	
Operating Temperature		T_A	-40	85	°C	Note 9
Lead Soldering Cycle	Temp.			260	°C	Note 1
	Time			10	sec	
Case Voltage		V_{CASE}		25	V	
Signal Pin Voltage		V_{SIGNAL}	-0.5	1	V	
Supply Voltage		V_{CC}	-0.5	7.0	V	

HFBR-2204 RECEIVER



Electrical/Optical Characteristics

-40° C to +85° C; $4.75 \le V_{CC} \le 5.25$; $R_{LOAD} = 511\Omega$ unless otherwise specified

Parameter	Symbol	Min.	Typ[4]	Max.	Unit	Conditions	Reference
Responsivitity	R_P	5.1	7	10.9	mV/μW	T_A = 25° C at 820 nm	Note 10 Figure 3
		4.6		12.3	mV/μW	-40 ≤ T_A ≤ +85° C	
RMS Output Noise Voltage	V_{NO}		.30	.36	mV	T_A = 25° C, P_{IN} = 0μW	Figures 4, 7
				.43	mV	-40 ≤ T_A ≤85° C, P_{IN}= 0 μW	
Peak Input Power	P_R			-12.6	dBm	T_A = 25° C	Note 2
				55	μW		
				-14	dBm	-40 ≤ T_A ≤ 85° C	
				40	μW		
Output Impedance	Z_O		20		Ω	Test Frequency = 20 MHz	
DC Output Voltage	V_{odc}		.7		V	P_{IN} = 0 μW	
Power Supply Current	I_{CC}		3.4	6.0	mA	R_{LOAD} = ∞	
Equivalent N.A.	NA		.35				
Equivalent Diameter	D_R		250		μm		Note 3
Equivalent Optical Noise Input Power	P_N		-43.7	-40.3	dBm		
			.042	.094	μW		

Dynamic Characteristics

-40° C to +85° C; $4.75 \le V_{CC} \le 5.25$; $R_{LOAD} = 511\Omega$, C_{LOAD} = 13 pF unless otherwise specified

Parameter	Symbol	Min.	Typ.[7]	Max.	Units	Conditions	Reference
Rise/Fall Time, 10% to 90%	t_r, t_f		14	19.5	ns	T_A = 25° C P_{IN} = 10 μW Peak	Note 5
				26	ns	-40 ≤ T_A ≤ 85° C	Figures 8, 9
Pulse Width Distortion	$t_{phl} - t_{plh}$			2	ns	P_{IN} = 40 μW Peak	Figure 9
Overshoot			4		%	T_A = 25° C	Note 6 Figures 8, 9
Bandwidth			25		MHz		
Power Supply Rejection Ratio (Referred to Output)	PSRR		50		dB	at 2 MHz	Note 7 Figures 5, 6

Notes:

1. 2.0 mm from where leads enter case.
2. If Pin < 40 μW, then pulse width distortion may increase. At Pin = 80 μW and T_A = 80° C, some units have exhibited as much as 100 ns pulse width distortion.

Notes (cont.):

3. D_R is the effective diameter of the detector image on the plane of the fiber face. The numerical value is the product of the actual detector diameter and the lens magnification.
4. Typical specifications are for operation at $T_A = 25°C$ and $V_{CC} = 5.0V$.
5. Input optical signal is assumed to have 10% — 90% rise and fall times of less than 6 ns.
6. Percent overshoot is defined as:

$$\frac{V_{PK} - V_{100\%}}{V_{100\%}} \times 100\%$$ See Figure 16.

7. Output referred P.S.R.R. is defined as

$$20 \log \left(\frac{V_{POWER\ SUPPLY\ RIPPLE}}{V_{OUT\ RIPPLE}} \right)$$

8. It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from pin 4 (V_{CC}) to pin 3 (circuit common) of the receiver. Total lead length between both ends of the capacitor and the pins should be less than 20 mm.
9. HP's 100/140 μm fiber cable is specified at a narrower temperature range, -20°C to 85°C.
10. $V_{OUT} = V_{ODC} - (R_P \times P_{IN})$.

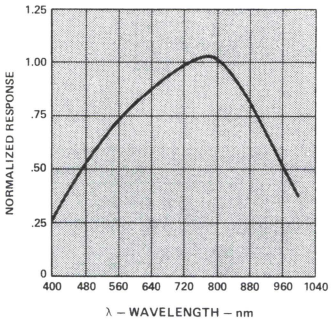


Figure 3. Receiver Spectral Response Normalized to 820 nm

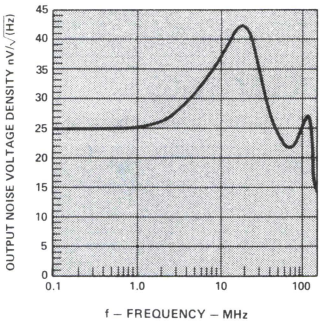


Figure 4. Receiver Noise Spectral Density

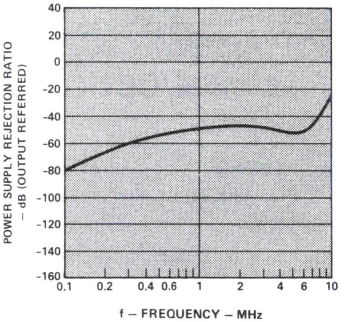


Figure 5. Receiver Power Supply Rej. vs. Freq.

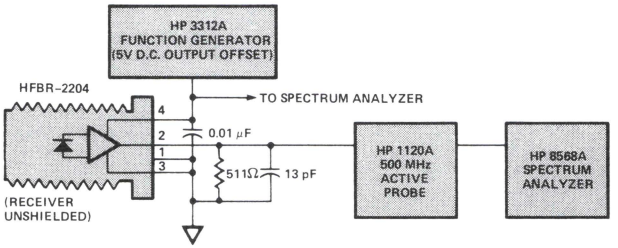


Figure 6. Power Supply Rejection Test Circuit

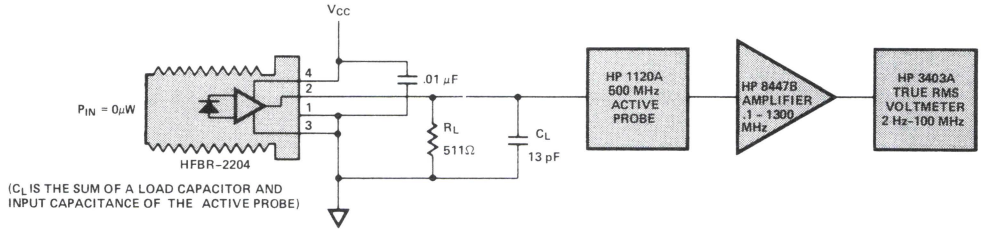


Figure 7. RMS Output Noise Voltage Test Circuit

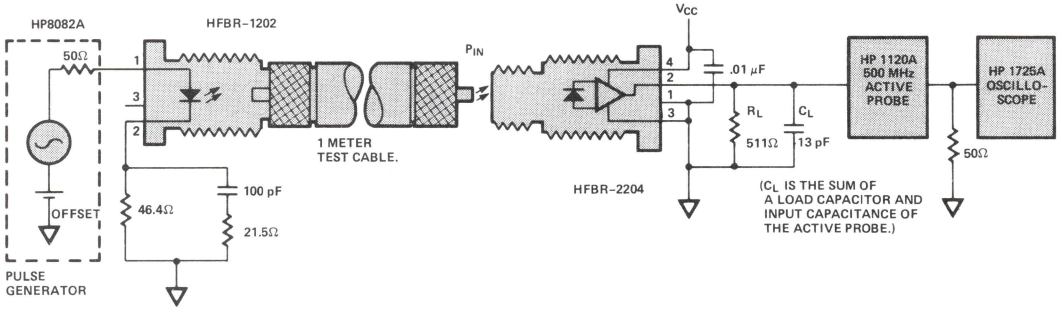


Figure 8. Rise and Fall Time Test Circuit

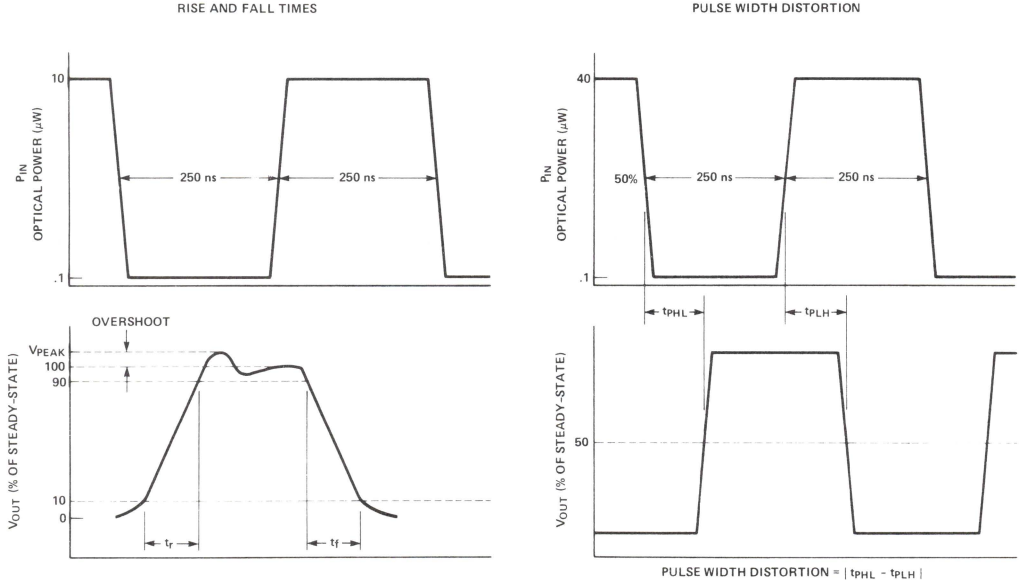


Figure 9. Waveform Timing Definitions

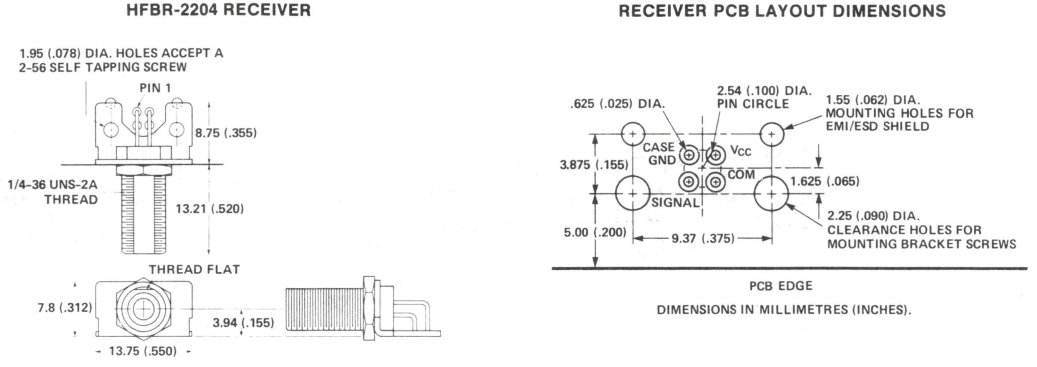


Figure 10. Mounting Dimensions

SMA STYLE CONNECTORS

TYPE A
(Used in HP's SMA Connectored Cable Assemblies).

TYPE B
(Not Available from Hewlett-Packard)

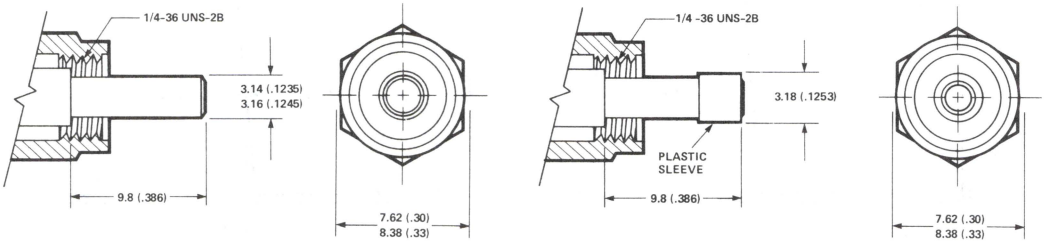


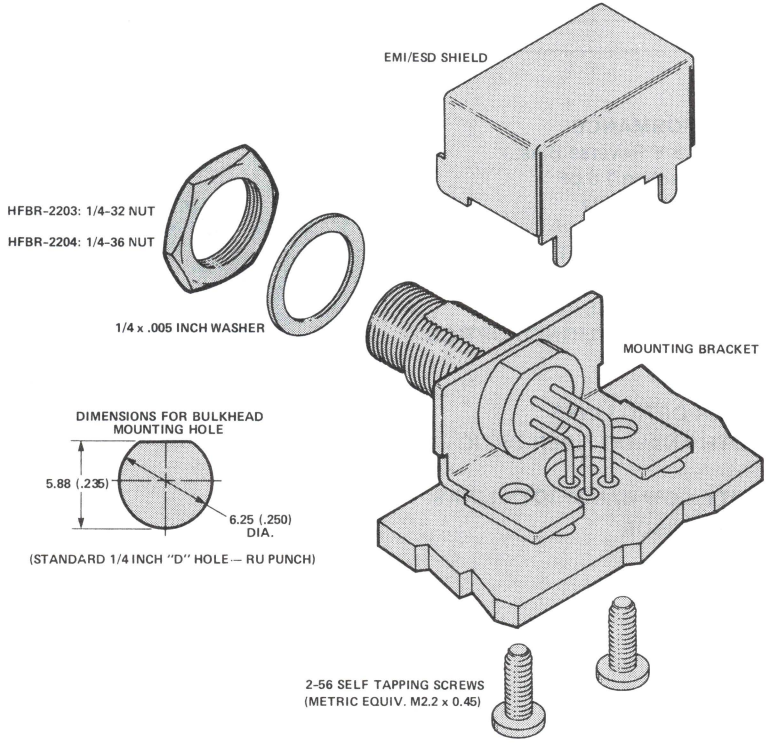
Figure 11. Fiber Optic Connector Styles

Horizontal PCB Mounting

Mounting at the edge of a printed circuit board with the lock nut overhanging the edge is recommended.

When bending the leads, avoid sharp bends right where the lead enters the backfill. Use needle nose pliers to support the leads at the base of the package and bend the leads as desired.

When soldering, it is advisable to leave the protective cap on the unit to keep the optics clean.



MOUNTING HARDWARE: HFBR-4202 (HFBR-2204)

1 EMI/ESD SHIELD
1 1/4-36 NUT
1 1/4 x .005 INCH WASHER
2 2-56 SELF TAPPING SCREWS
1 MOUNTING BRACKET

Ordering Guide

Transmitter: HFBR-1202 (SMA Connector Compatible)
HFBR-1204 (SMA Connector Compatible)

Receiver: HFBR-2204 (SMA Connector Compatible)

Mounting Hardware: HFBR-4202 (SMA Connector Compatible)

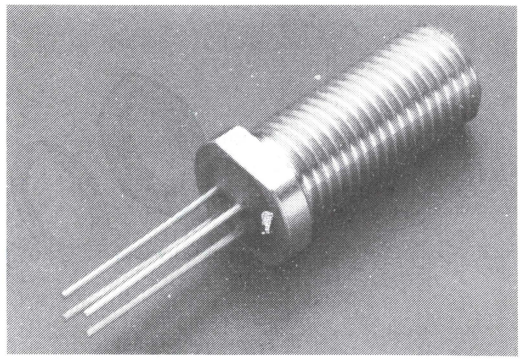
HEWLETT PACKARD

PIN PHOTODIODE FIBER OPTIC RECEIVER

HFBR-2208

Features

- **GUARANTEED PERFORMANCE:**
  60 MHz Bandwidth at 5 V Reverse Bias
  Low Capacitance: Less than 1.6 pF
  0.29 A/W Minimum Responsivity
  Low Dark Current: Less than 500 pA
- **MATES DIRECTLY WITH SMA STYLE CONNECTORS**
- **RUGGED, ISOLATED MINIATURE METAL PACKAGE WITH FACTORY ALIGNED OPTICS**



Applications

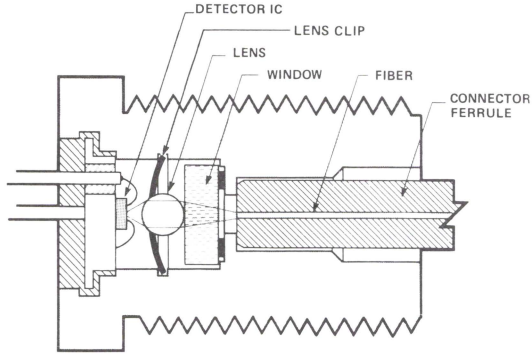
- **HIGH SPEED FIBER OPTIC LINKS**
- **WIDE BANDWIDTH ANALOG FIBER OPTIC LINKS**
- **HIGH SENSITIVITY, LOW BANDWIDTH LINKS**
- **OPTICAL POWER SENSOR**

Description

The HFBR-2208 Fiber Optic Receiver is a silicon PIN photodiode mounted in a rugged metal package. Well suited for high speed applications, the HFBR-2208 Fiber Optic Receiver has low capacitance and low noise. The high coupling efficiency of the miniature package provides a minimum of 0.29 A/W responsivity. Receiver responsivity includes the optical power lost in coupling light from the fiber onto the PIN photodiode as well as the responsivity of the PIN photodiode itself.

HFBR-2208 mates with SMA style connectors.

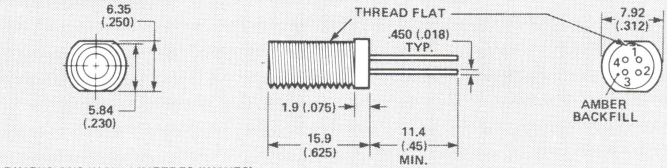
The HFBR-2208 is a member of the family of transmitters and receivers which use the miniature package. HP also offers connectored and unconnectored 100/140 μm fiber cable in simplex and duplex configurations.



Cross Sectional View

Mechanical Dimensions

HFBR-2208 SMA STYLE COMPATIBLE

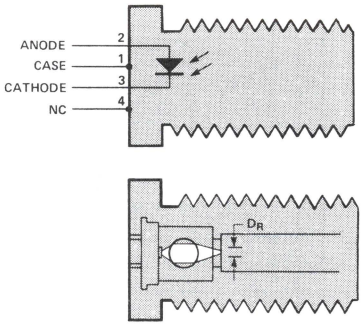


PIN	FUNCTION
1	CASE
2	ANODE
3	CATHODE
4	NC

DIMENSIONS IN MILLIMETRES (INCHES)

Absolute Maximum Ratings

Parameter		Symbol	Min.	Max.	Units	Reference
Storage Temperature		T_S	-55	85	°C	
Operating Temperature		T_A	-55	85	°C	
Lead Soldering Cycle	Temp.			260	°C	Note 1
	Time			10	sec	
Reverse Bias Voltage		V_R	-0.5	50	V	
Voltage, Case-to-Junction		V_C		100	V	Note 2



Electrical/Optical Characteristics

-55° C to +85° C; V_R = 5 V; P_R = -20 dBm at 820 nm unless otherwise specified. Typical data at T_A = 25° C.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Reference
Effective Optical Port DC Responsivity	R_P	0.29	0.38	0.40	A/W	HP's 100/140 μm Fiber N.A. = 0.3, g = 2	Fig. 1, 2, 3, 8
Dark Current	I_D		50	500	pA	T_A = 25° C, P_R = 0μW, V_R = 20 V	Fig. 4, 9
Noise Equivalent Power	NEP			3.4×10^{-14}	$\frac{W}{\sqrt{Hz}}$		Note 5
Total Capacitance	C_T		1.3	1.6	pF		Fig. 5
Series Resistance	R_S		5	15	Ω		
Equivalent N.A.	NA		0.4				
Equivalent Diameter	D_R		250		μm		Note 3
Case Isolation Resistance	R_{CASE}	1			MΩ	V_C = 100 V	Note 2, Fig. 9

Dynamic Characteristics

T_A = 25° C, R_{LOAD} = 50 Ω, P_R = -20 dBm at 820 nm unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Reference
3 dB Bandwidth	BW	60	100		MHz	V_R = 5 V	Fig. 6, 7
		150	250			V_R = 20 V	Fig. 10
Rise/Fall Time (10-90%)	t_r, t_f		3.5		ns	V_R = 5 V	Note 4
Relative Incremental Response	$\Delta R_P/R_P$		0.5		%	$P_R \leq$ -20 dBm, V_R = 5 V	Fig. 8 Note 6

Notes:

1. 2.0 mm from where leads enter case.
2. V_C (100 V) is applied simultaneously to Pin 2 and Pin 3 with respect to Pin 1.
3. D_R is the effective diameter of the detector image on the plane of the fiber face. The numerical value is the product of the actual detector diameter and the lens magnification.
4. Rise/Fall time is calculated from the equation:

$$t_r, t_f = \frac{350}{3 \text{ dB BW (MHz)}} \text{ ns}$$

5. For (λ, f, Δf) = (820 nm, 100 Hz, 6 Hz) where f is the frequency for a spot noise measurement and Δf is the noise bandwidth, NEP is the optical flux required for unity signal/-noise ratio normalized for bandwidth.

Thus:

$$NEP = \frac{I_N/\sqrt{\Delta f}}{R_P}$$

where $I_N/\sqrt{\Delta f}$ is the bandwidth — normalized noise current computed from the shot noise formula:

$I_N/\sqrt{\Delta f} = \sqrt{2qI_D} = 17.9 \times 10^{-15} \sqrt{I_D}$ (A/$\sqrt{Hz}$) where I_D is nA.

6. Relative incremental response is defined as:

$$\frac{\Delta R_P}{R_P} \times 100\% = \frac{R_{AC}(P_R) - R_{AC}(-25 \text{ dBm})}{R_{AC}(-25 \text{ dBm})} \times 100\%$$

where:
R_{AC} = Small signal AC (20 MHz, -30 dBm) response
P_R = DC optical power incident on port.

V_R = 5 V; P_R = −20 dBm at 820 nm; T_A = 25°C unless otherwise specified.

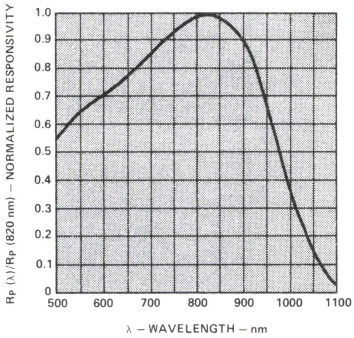


Figure 1. Normalized Responsivity vs. Wavelength

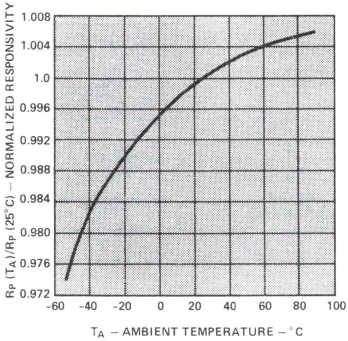


Figure 2. Normalized Responsivity vs. Ambient Temperature

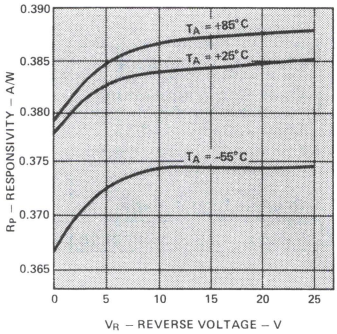


Figure 3. Responsivity vs. Reverse Voltage

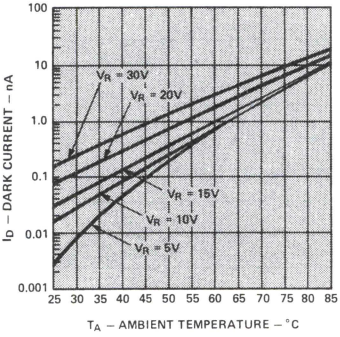


Figure 4. Dark Current vs. Ambient Temperature

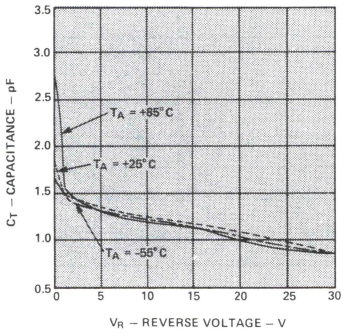


Figure 5. Capacitance vs. Reverse Voltage

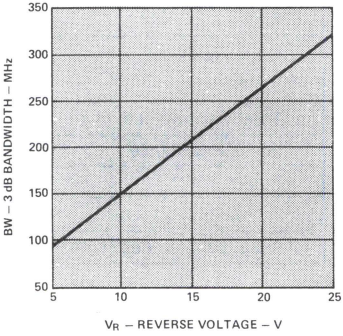


Figure 6. 3 dB Bandwidth vs. Reverse Voltage

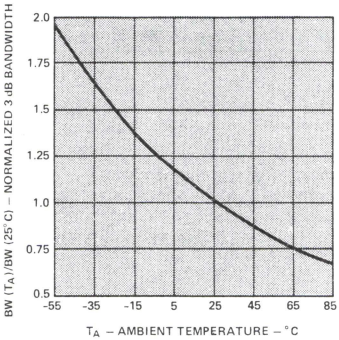


Figure 7. Normalized Bandwidth vs. Ambient Temperature

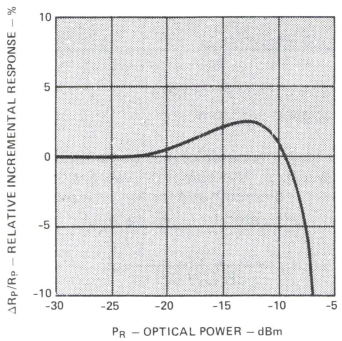


Figure 8. Linearity Characteristic vs. Optical Power

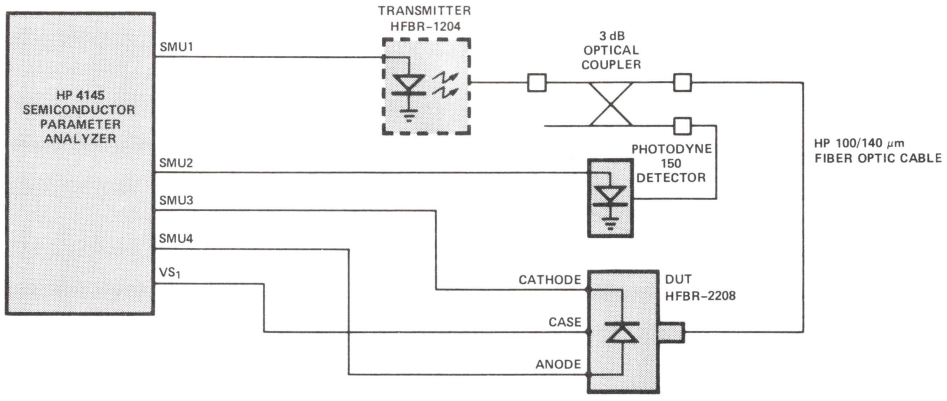


Figure 9. Test Set-up

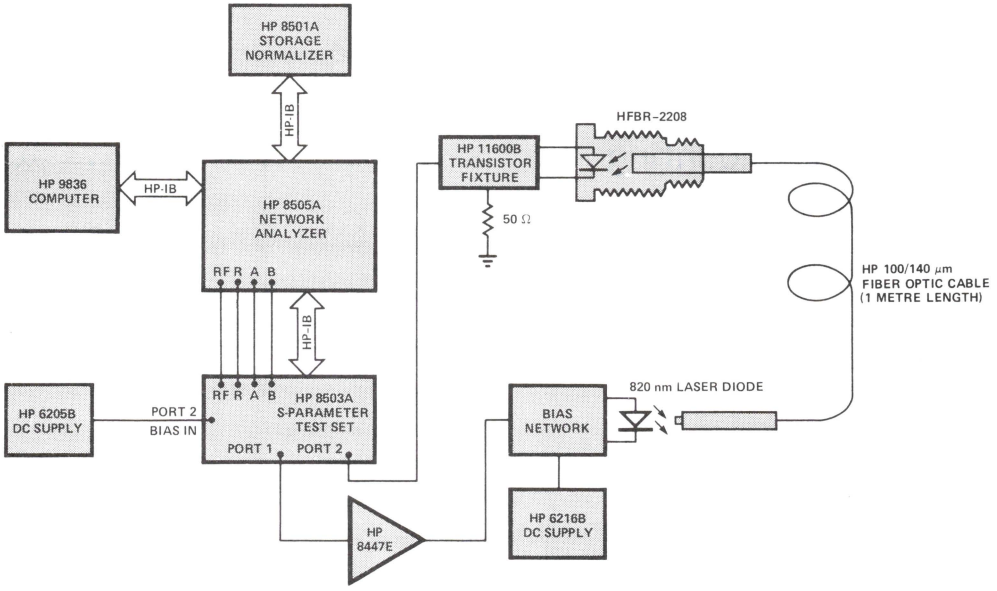
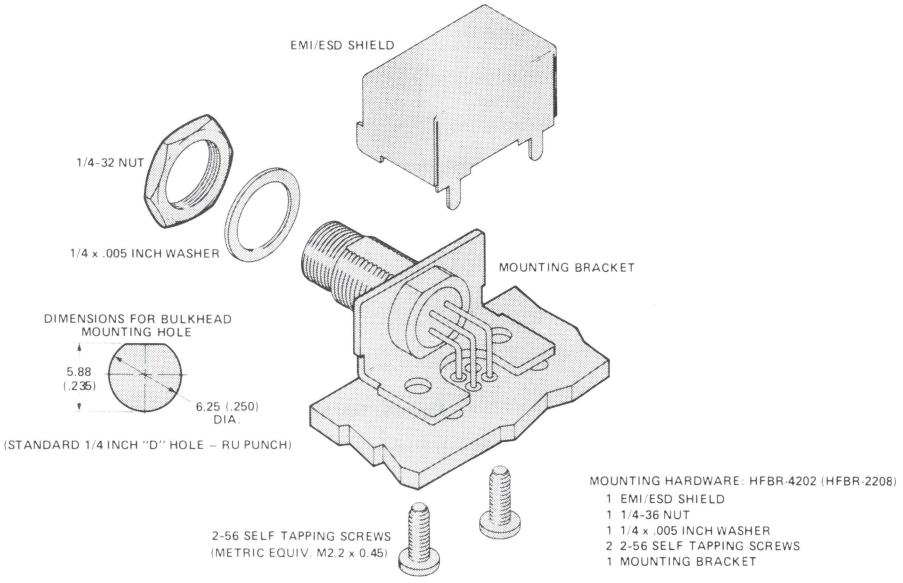


Figure 10. Bandwidth Measurement Set-up

Mechanical Description

The HFBR-2208 fiber optic receivers are housed in rugged metal packages intended for use with the SMA style connectored fiber cables. The low profile package is designed for direct mounting on printed circuit boards or through panels without additional heat sinking. A flat on the mounting threads of the device is provided to prevent rotation in all mounting configurations and to provide an orientation reference for the pin-out. Hardware is available for horizontal mounting applications on printed circuit boards. The hardware consists of a stainless steel mounting bracket fastened directly to the printed circuit board with two stainless steel self-tapping screws and a nut and washer for fastening the device in the bracket. A metal shield which snaps directly on the mounting bracket is also available for unusually severe EMI/ESD environments. When mounted in the horizontal configuration, the overall height of the component conforms with guidelines allowing printed circuit board spacing on 12.7 mm (0.500) centers. A thorough environmental characterization has been performed on these products. The test data as well as information regarding operation beyond the specified limits is available from any Hewlett-Packard sales office.

Good system performance requires clean port optics and cable ferrules to avoid obstructing the optical path. Clean compressed air often is sufficient to remove particles of dirt; methanol or Freon™ on a cotton swab also works well.



Horizontal PCB Mounting

Mounting at the edge of a printed circuit board with the lock nut overhanging the edge is recommended.

When bending the leads, avoid sharp bends right where the lead enters the backfill. Use needle nose pliers to support the leads at the base of the package and bend the leads as desired.

When soldering, it is advisable to leave the protective cap on the unit to keep the optics clean.

Application Information

NOISE FREE PROPERTIES

The noise current of the HFBR-2208 is negligible. This is a direct result of the exceptionally low leakage current, in accordance with the shot noise formula $I_N = (2qI_D\Delta f)^{1/2}$. Since the leakage current does not exceed 500 picoamps at a reverse bias of 20 volts, shot noise current is less than 9.8×10^{-15} amp $Hz^{-1/2}$ at this voltage.

Excess noise is also very low, appearing only at frequencies below 10 Hz, and varying approximately as 1/f. When the output of the diode is observed in a load, thermal noise of the load resistance (R_L) is $1.28 \times 10^{-10} (R_L)^{-1/2} \times (\Delta f)^{1/2}$ at 25° C, and far exceeds the diode shot noise for load resistance less than 100 megohms. Thus in high frequency operation where low values of load resistance are required for high cut-off frequency, the HFBR-2208 contributes virtually no noise to the system.

HIGH SPEED PROPERTIES

High speed operation is possible since the HFBR-2208 has low capacitance and wide bandwidth at a low reverse bias.

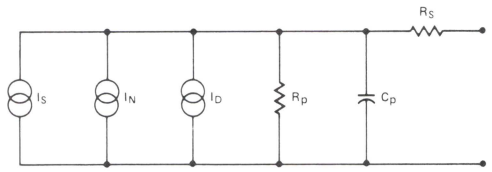


Figure 11. Photodiode Equivalent Circuit

I_S = Signal current ≈ 0.38 μA/μW x P_R
I_N = Shot noise current
< 9.8×10^{-15} amps/$Hz^{1/2}$

I_D = Dark current
< 500×10^{-12} amps at 20 V dc bias

$R_P = 10^{11}\ \Omega$
R_S = <50 Ω

LINEAR OPERATION

Operation of the photodiode is most linear when operated with a current amplifier as shown in Figure 12.

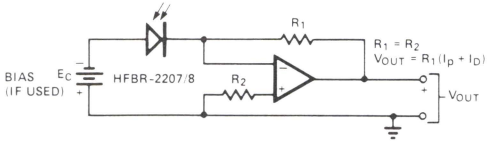
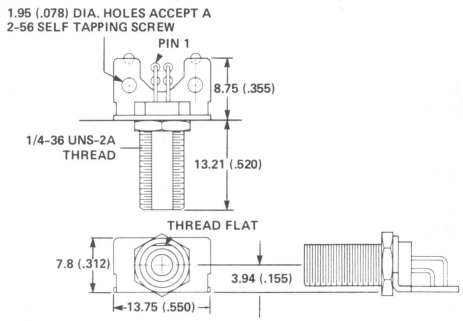


Figure 12. Linear Operation

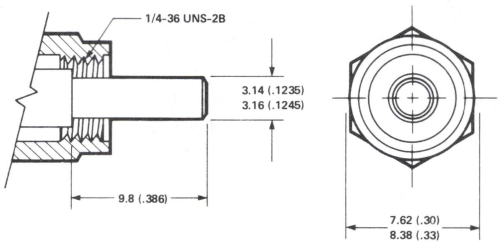
Lowest noise is obtained with $E_C = 0$, but higher speed and wider dynamic range are obtained if $5 < E_C < 20$ volts. The amplifier should have as high an input resistance as possible to permit high loop gain. If the photodiode is reversed, bias should also be reversed.

HFBR-2208 RECEIVER

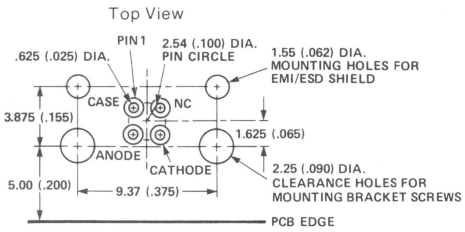


SMA STYLE CONNECTORS TYPE A

(Used on HP's 100/140 μm fiber optic cable)

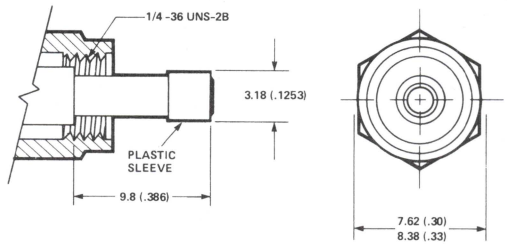


RECEIVER PCB LAYOUT DIMENSIONS



SMA STYLE CONNECTORS TYPE B

(Type B is not available from HP)



DIMENSIONS IN MILLIMETRES (INCHES).

Ordering Guide

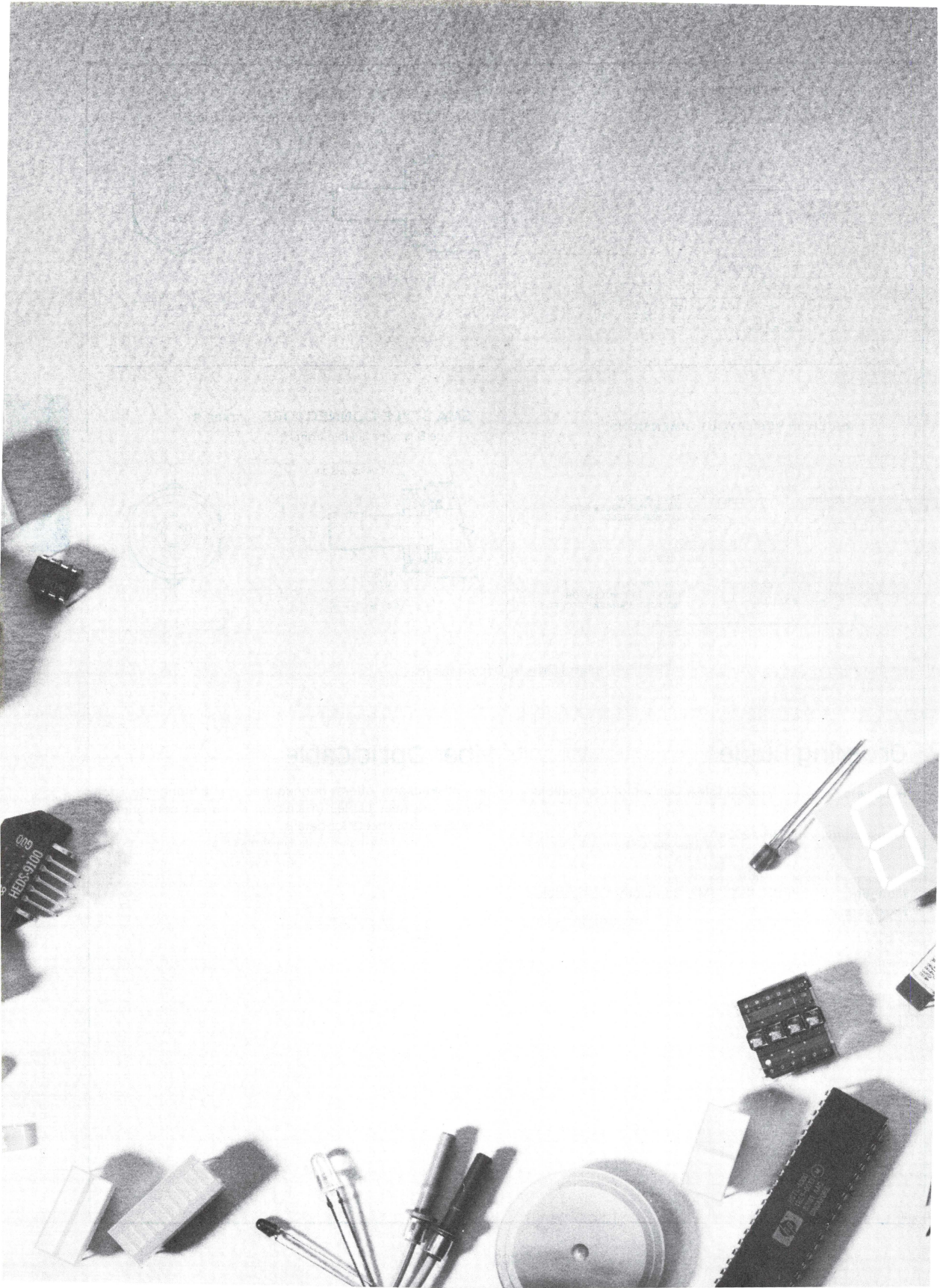
Receivers: HFBR-2208 (SMA Connector Compatible)

Transmitters: HFBR-1202
HFBR-1204
(see data sheets)

Mounting Hardware: HFBR-4202 (SMA Connector Compatible)

Fiber Optic Cable

Hewlett-Packard offers connectored or unconnectored 100/140 μm fiber cables in simplex or duplex configurations. See data sheets for details.


HEDS-9100

Optocouplers

- High Speed Optocouplers
- Low Current Optocouplers
- High Gain Optocouplers
- Application Specific Optocouplers
- Hermetic Optocouplers

Optocouplers

Hewlett-Packard's original approach toward integrated output detectors provides performance not found in conventional phototransistor output devices. A family of optocouplers has been established to provide reliable, economical, high performance solutions to problems caused by ground loops and induced common mode noise for both analog and digital applications in commercial, industrial, and military products.

This family spans a wide range of capabilities. Device selections include: programmable AC/DC power sensing input with logic output; speeds up to 40 Mbit/s; CTR gains as high as 2000% and input currents as low as 0.5 mA. We also have available highly linear optocouplers that are useful in analog applications, a unique integrated-input optically coupled line receiver that can be connected directly to twisted pair wires without additional circuitry, and optocouplers that provide complete isolated transmit and receive functions for a 20 mA current loop.

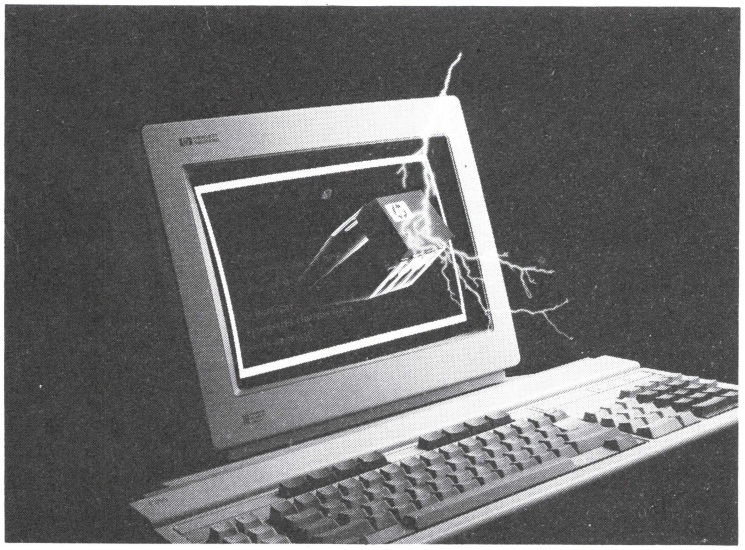
Many of these devices are available in dual channel versions as well as in hermetic 8 and 16 pin DIP packages. For military users, Hewlett-Packard's established, and DESC recognized hi-rel capability facilitates economical, hi-rel purchases.

Plastic Optocouplers

Put an end to erroneous data, false control signals, and damaged circuits with HP's line of high-performance plastic optocouplers. There are five basic families of optocouplers to choose from: high-speed logic gate, high-speed transistor output, high-gain, AC/DC to logic interface, and 20 mA current loop. All plastic optocouplers are UL approved, and are available with high-voltage (2,500 Vac) and surface mount options.

New this year are seven optocouplers featuring improved common mode noise rejection capabilities. The HCPL-2211, HCPL-2212, HCPL-2232, HCPL-2411, HCPL-2611, HCPL-2612, and the HCPL-4661 all provide at least 3,500 V/μs isolation with a Vcm of 300 V. We are able to provide this enhanced performance through a breakthrough in the design of the internal Faraday shield.

Also new this year is the availability of quality and reliability data sheets, which are updated quarterly. This data has helped many of our customers eliminate incoming inspection by knowing our actual outgoing quality levels. Please call your local HP sales office for more information about these programs.

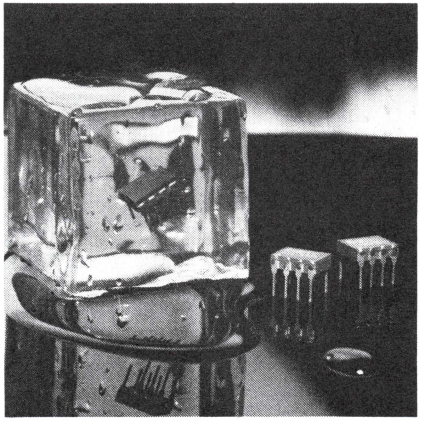


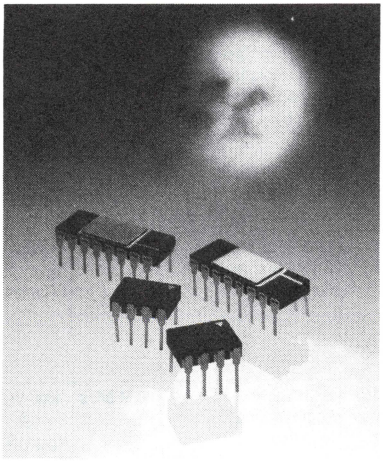
Hermetic Optocouplers

Choose from Hewlett-Packard's broad line of high performance 8 and 16 pin hermetic optocouplers to meet your military, aerospace and high reliability applications. There are three basic families of optocouplers to select from in each package configuration. The 8 pin dual in-line package (DIP) features: high speed logic gates, high gain, and AC/DC to logic interface devices. The 16 pin DIP contains: high speed transistor, high speed logic gate, and high gain devices. Most 8 pin devices allow a choice of either single or dual channels. The 16 pin units consist of three dual channel and one four channel devices.

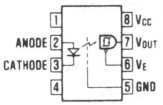
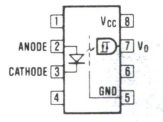
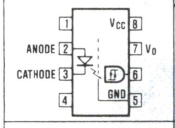
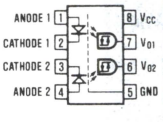
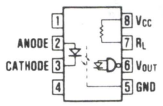
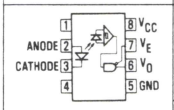
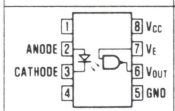
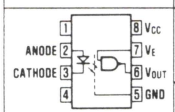
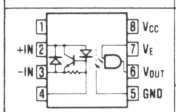
New this year for all devices manufactured from this line is our recently acquired hybrid line certification and qualification to MIL-STD-1772. In addition to the added value obtained from purchasing hi-rel tested parts to MIL-STD-883 Class B or S, line certification assures our customers of continuing assembly compliance to approved manufacturing processes and procedures under the watchful eye of periodic DESC audits.

Also new this year are eight logic gate, and two AC/DC to logic interface units in the 8 pin DIP. And, to give you added protection for common mode, we now include a shield on the detector die of all 16 pin DIP devices.



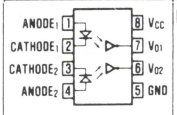
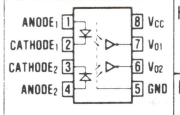


High-Speed Logic Gate Optocouplers

Device		Description	Application[1]	Typical Data Rate [NRZ]	Guaranteed CMR	Specified Input Current	Withstand Test Voltage		Page No.
							Standard*	Option 010**	
	HCPL-2200	3 State Output Low Input Current Optically Coupled Logic Gate V_{CC} = 20 V Max.	High Speed Logic Ground Isolation LSTTL, TTL, CMOS Logic Interference	5 M bit/s	1000 V/μs @ V_{CM} = 50 V	1.6 mA	3000 V dc	2500 V ac	9-11
	HCPL-2201 HCPL-2202	Low Input Current Optically Coupled Logic Gate V_{CC} = 20 V Max.			1000 V/μs @ V_{CM} = 50 V				9-15
	HCPL-2211 HCPL-2212		Motor Controls Switch-mode Power Supplies Electrically Noisy Environments		5000 V/μs @ V_{CM} = 300 V				
	HCPL-2231	Dual Channel Low Input Current Optically Coupled Logic Gate V_{CC} = 20 V Max	High Speed Logic Ground Isolation LSTTL, TTL, CMR Logic Interface	5 M bit/s	1000 V/μs @ V_{CM} = 50 V	1.8 mA	3000 V dc	2500 V ac	9-19
	HCPL-2232		Motor Controls Switch-mode Power Supplies Electrically Noise Environments		5000 V/μs @ V_{CM} = 300 V				
	HCPL-2300	Very Low Input Current, High Speed Optocoupler	High Speed, Long Distance Line Receiver, Computer Peripheral Interfaces CMOS Logic Interface	8 M bit/s	100 V/μs @ V_{CM} = 50 V	0.5 mA	3000 V dc	2500 V ac	9-23
	HCPL-2400	20 MBaud, High Common Mode Rejection, Optically Coupled Logic Gate 3 State Output	Very High Speed Logic Isolation A/D and Parallel to Serial Conversion	4.0 M bit/s	1000 V/μs @ V_{CM} = 50 V	4.0 mA	3000 V dc	2500 V dc	9-29
	HCPL-2411		Motor Controls Switch-mode Power Supplies Electrically Noise Environments		5000 V/μ @ V_{CM}=300V				
	6N137	Optically Coupled Logic Gate	Line Receiver, High Speed Ground Isolation	10 m bit/s	>100 V/μs V_{CM} = 10 V (Typical)	5.0 mA	3000 V dc	2500 V ac	9-35
	HCPL-2601	High Common Mode Rejection, Optically Coupled Logic Gate	High Speed Logic Ground Isolation	10 M bit/s	1000 V/μs @ V_{CM} = 50 V	5.0 mA	3000 V dc	2500 V ac	9-39
	HCPL-2611		Motor Controls Switch-mode Power Supplies Electrically Noisy Environments		5000 V/μs @ V_{CM}=300V				
	HCPL-2602	Optically Coupled Line Receiver	Replace Conventional Line Receivers	10 M bit/s	1000 V/μs @ V_{CM} = 50 V	5.0 mA	3000 V dc	2500 V ac	9-43
	HCPL-2612		Electrically Noisy Environments		5000 V/μs @ V_{CM}=300V				

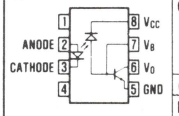
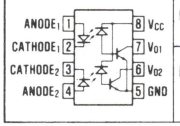
*Standard Parts meet the UL1440 V ac test for 1 minute.
**Option 010 parts meet the UL 2500 V ac test for 1 minute.

High-Speed Logic Gate Optocouplers

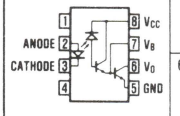
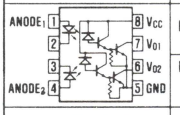
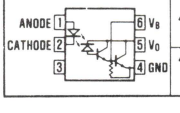
Device		Description	Application[1]	Typical Data Rate (NRZ)	Guaranteed Ratio	Specified Input Current	Withstand Test Voltage		Page No.
							Standard*	Option 010**	
	HCPL-2630	Dual Channel Optically Coupled Gate	Line Receiver, High Speed Logic Ground Isolation	10 M bit/s	>100 V/μs @ V_{CM} = 10 V (Typical)	5.0 mA	3000 V dc	2500 V ac	9-49
	HCPL-2631	Dual Channel, High Common Mode Rejection, Optically Coupled Logic Gate	High Speed Logic Ground Isolation	10 M bit/s	1000 V/μs @ V_{CM} = 50 V	5.0 mA	3000 V dc	2500 V ac	9-53
	HCPL-4661		Motor Controls Switch-mode Power Supplies Electrically Noisy Environments		5000 V/μs @ V_{CM}=300V				

*Standard Parts meet the UL1440 V ac test for 1 minute.
**Option 010 parts meet the UL 2500 V ac test for 1 minute.

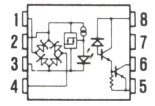
High-speed Transistor Output Optocouplers

Device		Description	Application[1]	Typical Data Rate (NRZ)	Current Transfer Ratio	Specified Input Current	Withstand Test Voltage		Page No.
							Standard*	Option 010**	
	6N135	Transistor Output	Line Receiver, Analog Circuits, TTL/CMOS, TTL/LSTTL Ground Isolation	1 M bit/s	7% Min.	16 mA	3000 V dc	2500 V ac	9-57
	6N136				19% Min.				
	HCPL-4502	Pin 7 Not Connected							
	HCPL-2502				15-22%				
	SL5505		Telephone circuits, Approved by CNET	1 M bit/s	15% Min. 40% Max.	16 mA	1500 V dc		9-61
	HCPL-2530	Dual Channel Transistor Output	Line Receiver, Analog Circuits, TTL/CMOS, TTL/LSTTL Ground Isolation	1 M bit/s	7% Min.	16 mA	3000 V dc	2500 V ac	9-63
	HCPL-2531				19% Min.				

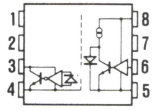
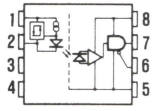
High Gain Optocouplers

Device		Description	Application[1]	Typical Data Rate (NRZ)	Current Transfer Ratio	Specified Input Current	Withstand Test Voltage		Page No.
							Standard*	Option 010**	
	6N138	Low Saturation Voltage, High Gain Output, V_{CC} = 7 V Max.	Line Receiver, Low Current Ground Isolation, TTL/TTL, LSTTL/TTL, CMOS/TTL	100k bit/s	300% Min.	1.6 mA	3000 V dc	2500 V ac	9-67
	6N139	Low Saturation Voltage, High Gain Output, V_{CC} = 18 V Max.	Line Receiver, Ultra Low Current Ground Isolation, CMOS/LSTTL, CMOS/TTL, CMOS/CMOS		400% Min.	0.5 mA			
	HCPL-2730	Dual Channel, High Gain, V_{CC} = 7 V Max.	Line Receiver, Polarity Sensing, Low Current Ground Isolation	100k bit/s	300% Min.	1.6 mA	3000 V dc	2500 V ac	9-71
	HCPL-2731	Dual Channel, High Gain, V_{CC} = 18 V Max.			400% Min.	0.5 mA			
	4N45	Darlington Output V_{CC} = 7 V Max.	AC Isolation, Relay-Logic Isolation	3k bit/s	250% Min.	1.0 mA	3000 V dc	2500 V ac	9-75
	4N46	Darlington Output V_{CC} = 20 V Max.			350% Min.	0.5 mA			

AC/DC to Logic Interface Optocoupler

Device		Description	Application[1]	Typical Data Rates	Input Threshold Current	Output Current	Withstand Test Voltage		Page No.
							Standard*	Option 010**	
	HCPL-3700	AC/DC to Logic Threshold Sensing Interface Optocoupler	Limit Switch Sensing, Low Voltage Detector, Relay Contact Monitor	4 KHz	2.5 mA TH^+ 1.3 mA TH^-	4.2 mA	3000 V dc UL	2500 V ac UL	9-79

20 mA Current Loop Optocouplers

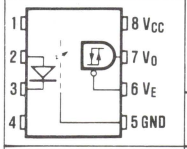
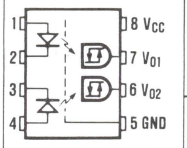
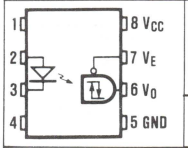
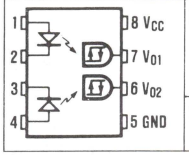
Device		Description	Application[1]	Typical Data Rates	Input Char-acteristics	Output Char-acteristics	Withstand Test Voltage		Page No.
							Standard*	Option 010**	
	HCPL-4100	Optically Coupled 20 mA Current Loop Transmitter	Isolated 20 mA Current Loop in: • Computer Peripherals • Industrial Control Equipment • Data Communication Equipment	20 kBd (at 400 metres)	TTL/CMOS	27 V Max. Compliance Voltage	3000 V dc UL	2500 V ac UL	9-85
	HCPL-4200	Optically Coupled 20 mA Current Loop Receiver			6.5 mA Typ. Threshold Current	3 State Output			9-93

Optocoupler Options

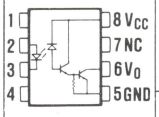
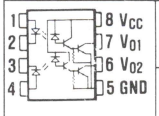
Option	Description	
010	Special construction and testing to ensure the capability to withstand 2500 V ac input to output for one minute. Testing is recognized by Underwriters Laboratories, Inc. (File No. E55361). This specification is required by U.L. in some applications where working voltages can exceed 220 V ac.	9-9
100	Surface mountable optocoupler in a standard sized dual-in-line package with leads trimmed (butt joint). Provides an optocoupler which is compatible with surface mounting processes.	9-10

*Standard Parts meet the UL1440 V ac test for 1 minute.
**Option 010 parts meet the UL 2500 V ac test for 1 minute.

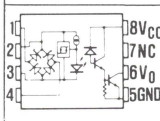
8 Pin Dual-In-Line Package
High-Speed Logic Gate Optocouplers

Device		Description	Application	Typical Data Rate [NRZ]	Common Mode	Specified Input Current	Withstand Test Voltage*	Page No.
	HCPL-5200	Single Channel, Hermetically Sealed Wide Supply Voltage Optocoupler	High Speed Logic Ground Isolation, LSTTL, TTL, CMOS Logic Interface	5 M bit/s	1000 V/μs	6.0 mA	500 Vdc	9-102
	HCPL-5201	MIL-STD-883 Class B	Military/High Reliability					
	HCPL-5230	Dual Channel, Hermetically Sealed Wide Supply Voltage Optocoupler	High Speed Logic Ground Isolation, LSTTL, TTL, CMOS Logic Interface					9-108
	HCPL-5231	MIL-STD-883 Class B Part	Military/High Reliability					
	HCPL-5400	Single Channel Hermetically Sealed High Speed Optocoupler	High Speed Logic Isolation, A/D and Parallel/Serial Conversion	40 M bit/s	500 V/μs	9.0 mA	500 Vdc	9-114
	HCPL-5401	MIL-STD-883 Class B Part	Military/High Reliability					
	HCPL-5430	Dual Channel Hermetically Sealed High Speed Optocoupler	High Speed Logic Isolation, Communications, Networks, Computers					9-120
	HCPL-5431	MIL-STD-883 Class B Part	Military/High Reliability					

High Gain Optocouplers

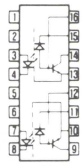
Device		Description	Application	Typical Data Rate (NRZ)	Current Transfer Ratio	Specified Input Current	Withstand Test Voltage	Page No.
	HCPL-5700	Single Channel Hermetically Sealed High Gain Optocoupler	Line Receiver, Low Current Ground Isolation, TTL/TTL, LSTTL/TTL, CMOS/TTL	60k bit/s	200% Min.	0.5 mA	500 V dc	9-126
	HCPL-5701	MIL-STD-883 Class B Part	Military/High Reliability					
	HCPL-5730	Dual Channel Hermetically Sealed High Gain Optocoupler	Line Receiver, Polarity Sensing, Low Current Ground Isolation					9-130
	HCPL-5731	MIL-STD-883 Class B Part	Military/High Reliability					

AC/DC to Logic Interface Optocoupler

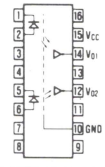
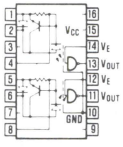
Device		Description	Application	Typical Data Rate	Input Threshold Current	Output Current	Withstand Test Voltage	Page No.
	HCPL-5760	Single Channel Hermetically Sealed Threshold Sensing Optocoupler	Limit Switch Sensing, Low Voltage Detector Relay Contact Montitor	10 kHz	2.5 mA TH+ 1.3 mA TH-	2.6 mA	500 V dc	9-134
	HCPL-5761	MIL-STD-883 Class B Part	Military/High Reliability					

16 Pin Dual In-Line Package

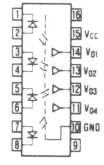
High Speed Transistor Optocouplers

Device		Description	Application	Typical Data Rate (NRZ)	Current Transfer Ratio	Specified Input Current	Withstand Test Voltage	Page No.
	4N55	Dual Channel Hermetically Sealed Analog Optical Coupler	Line Receiver, Analog Signal Ground Isolation, Switching Power Supply Feedback Element	700k bit/s	9% Min.	16 mA	1500 V dc	9-140
	4N55/883B	MIL-STD-883 Class B Part	Military/High Reliability					

High Speed Logic Gate Optocouplers

Device		Description	Application	Typical Data Rate (NRZ)	Common Mode	Specified Input Current	Withstand Test Voltage	Page No.
	6N134	Dual Channel Hermetically Sealed Optically Coupled Logic Gate	Line Receiver, Ground Isolation for High Reliability Systems	10M bit/s	1000 V/μs	10 mA	1500 V dc	9-145
	8102801EC	DESC Approved 6N134	Military/High Reliability					9-149
	HCPL-1930	Dual Channel Hermetically sealed High CMR Line Receiver Optocoupler	Line receiver, High Speed Logic Ground Isolation in High Ground or Induced Noise Environments	10M bit/s	1000 V/μs	10 mA	1500 Vdc	9-153
	HCPL-1931	MIL-STD-883 Class B Part	Military/High Reliability					

High Gain Optocouplers

Device		Description	Application	Typical Data Rate (NRZ)	Current Transfer Ratio	Specified Input Current	Withstand Test Voltage	Page No.
	6N140A (6N140)	Hermetically Sealed Package Containing 4 Low Input Current, High Gain Optocouplers	Line Receiver, Low Power Ground Isolation for High Reliability Systems	100k bit/s	300% Min.	0.5 mA	1500 V dc	9-159
	8302401EC	DESC Approved 6N140A	Military/High Reliability					9-163
	6N140A/883B (6N140/883B)	MIL-STD-883 Class B Part	Use 8302401EC in New Designs					9-159

HEWLETT PACKARD

OPTOCOUPLER OPTION FOR 2500 Vac/ 1 MINUTE REQUIREMENT

OPTION 010

Features

- **SPECIAL CONSTRUCTION AND TESTING**
- **UL RECOGNITION FOR 2500 V ac/1 MINUTE REQUIREMENT (FILE NO. E55361)**
- **AVAILABLE FOR ALL PLASTIC OPTOCOUPLERS**
- **480 V ac LINE VOLTAGE RATING**

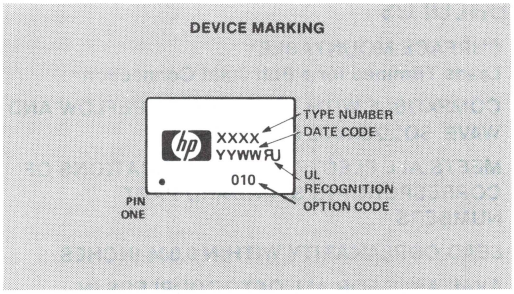
Description

Option 010 consists of special construction on a wide range of Hewlett-Packard plastic optocouplers. After assembly, each unit is subjected to an equivalent electrical performance test to insure its capability to withstand 2500 Vac input to output for 1 minute. This test is recognized by Underwriters Laboratory as proof that these components may be used in many high voltage applications.

Applications

The 2500 Vac/1 Minute dielectric withstand voltage is required by Underwriters Laboratory when components are used in certain types of electronic equipment. This requirement also depends on the specific application within the equipment. Some applicable UL documents are listed below.

UL Spec. Number	Specification Title
1577	Standard for Optical Isolators Applications
114	Appliance and Business Equipment
347	High Voltage Industrial Control Equipment
478	Information Processing and Business Equipment
508	Industrial Control Equipment
544	Medical and Dental Equipment
698	Industrial Control Equipment for Use in Hazardous Locations
773	Plug-in, Locking Type Photocontrols
913	Intrinsically Safe Apparatus and Associated Apparatus
916	Standard for Energy Management Equipment
1012	Power Supplies
1244	Electrical and Electronic Measuring and Testing Equipment
1410	Television and Video Products



Specifications

All specifications for optocouplers remain unchanged when this option is ordered. The 2500 Vac/1 Minute capability is validated by a factory 3200 Vac/1 Second dielectric voltage withstand test.

Ordering Information

To obtain this high voltage capability on plastic optocouplers order the standard part number and Option 010.

Examples:

6N135	HCPL-3700
Option 010	Option 010

This option is currently available on all standard catalog plastic optocouplers except SL5505.

HEWLETT PACKARD

SURFACE MOUNT OPTION FOR OPTOCOUPLERS

OPTION 100

Features

- **SURFACE MOUNTABLE**
  Leads Trimmed for a Butt Joint Connection
- **COMPATIBLE WITH VAPOR PHASE REFLOW AND WAVE SOLDERING PROCESSES**
- **MEETS ALL ELECTRICAL SPECIFICATIONS OF CORRESPONDING STANDARD PART NUMBERS**
- **LEAD COPLANARITY WITHIN 0.004 INCHES**
- **AVAILABLE FOR ALL OPTOCOUPLERS IN PLASTIC PACKAGES**
- **AVAILABLE IN STANDARD SHIPPING TUBES**

Description

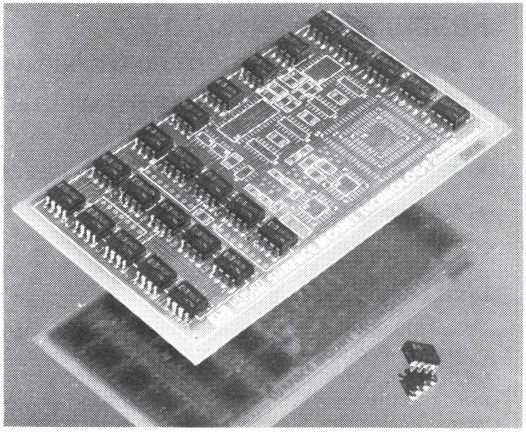
Option 100 is an optocoupler in a standard sized dual-in-line package, with trimmed leads (butt joint). The distance from the printed circuit board (PCB), to the bottom of the optocoupler package, will be typically 0.035 inches. The height of the optocoupler package is typically 0.150 inches, leaving a distance of 0.185 inches from PCB to the top of the optocoupler package.

Applications

Option 100 enables electronic component assemblers to include HP optocouplers on a PCB that utilizes surface-mount assembly processes. Option 100 does not require "through holes" in a PCB. This reduces board costs, while potentially increasing assembly rates and increasing component density per board.

Specifications

All electrical specifications for optocouplers remain unchanged when this option is ordered. In addition, the device will withstand typical vapor phase reflow soldering conditions of 215°C for 30 seconds, and wave solder immersion for 5 seconds, @ 260°C.



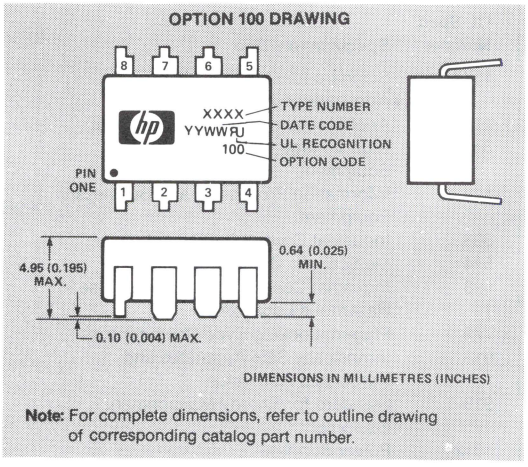
Ordering Information

Option 100 is available for all optocouplers in plastic packages.

To obtain surface-mountable optocouplers, order the standard part number and Option 100.

Examples:

6N136	HCPL-2200
Option 100	Option 100

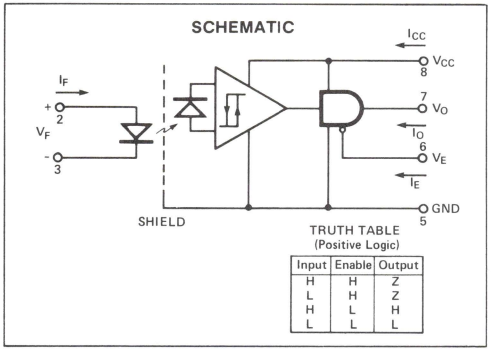


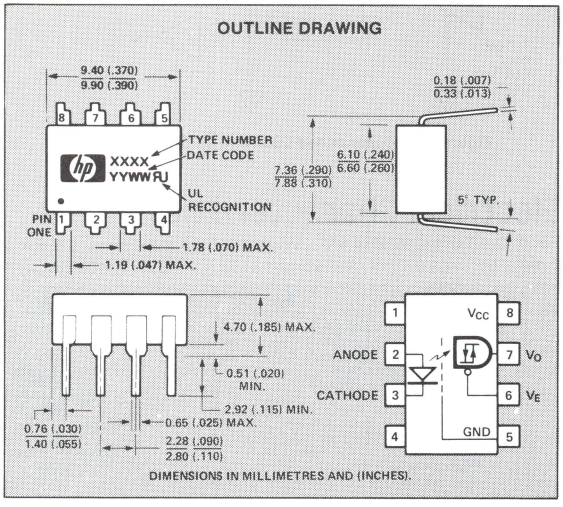
Note: For complete dimensions, refer to outline drawing of corresponding catalog part number.

HEWLETT PACKARD

LOW INPUT CURRENT LOGIC GATE OPTOCOUPLER

HCPL-2200





Features

- **COMPATIBLE WITH LSTTL, TTL, AND CMOS LOGIC**
- **WIDE V_{CC} RANGE (4.5 TO 20 VOLTS)**
- **2.5 MBAUD GUARANTEED OVER TEMPERATURE**
- **LOW INPUT CURRENT (1.6 mA)**
- **THREE STATE OUTPUT (NO PULLUP RESISTOR REQUIRED)**
- **GUARANTEED PERFORMANCE FROM 0° C TO +85° C**
- **INTERNAL SHIELD FOR HIGH COMMON MODE REJECTION**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**
- **HCPL-5200/1 COMPATIBILITY**

Applications

- **Isolation of High Speed Logic Systems**
- **Computer-Peripheral Interfaces**
- **Microprocessor System Interfaces**
- **Ground Loop Elimination**
- **Pulse Transformer Replacement**
- **Isolated Buss Driver**
- **High Speed Line Receiver**

Description

The HCPL-2200 is an optically coupled logic gate that combines a GaAsP LED and an integrated high gain photon detector. The detector has a three state output stage and has a detector threshold with hysteresis. The three state output eliminates the need for a pullup resistor and allows for direct drive of data busses. The hysteresis provides differential mode noise immunity and eliminates the potential for output signal chatter. The detector IC has an internal shield that provides a guaranteed common mode transient immunity of 1,000 volts/μsec. Higher CMR specifications are available upon request. Improved power supply rejection eliminates the need for special power supply bypassing precautions.

The Electrical and Switching Characteristics of the HCPL-2200 are guaranteed over the temperature range of 0° C to 85° C. The HCPL-2200 is guaranteed to operate over a V_{CC} range of 4.5 volts to 20 volts. Low I_F and wide V_{CC} range allow compatibility with TTL, LSTTL, and CMOS logic. Low I_F and low I_{CC} result in lower power consumption compared to other high speed optocouplers. Logic signals are transmitted with a typical propagation delay of 160 nsec.

The HCPL-2200 is useful for isolating high speed logic interfaces, buffering of input and output lines, and implementing isolated line receivers in high noise environments.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.5	20	Volts
Enable Voltage High	V_{EH}	2.0	20	Volts
Enable Voltage Low	V_{EL}	0	0.8	Volts
Forward Input Current	$I_{F(ON)}$	1.6	5	mA
Forward Input Current	$I_{F(OFF)}$	—	0.1	mA
Operating Temperature	T_A	0	85[1]	°C
Fan Out	N		4	TTL Loads

OPTOCOUPLERS

Recommended Circuit Design

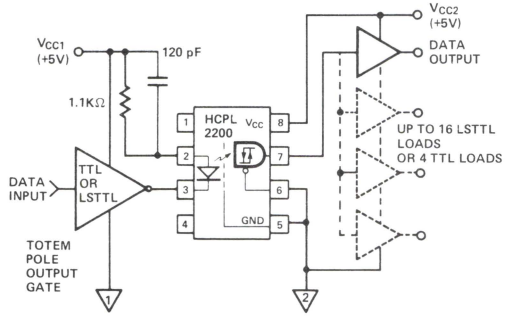


Figure 1. Recommended LSTTL to LSTTL Circuit

Absolute Maximum Ratings

(No Derating Required up to 70° C)

Storage Temperature ..... -55° C to +125° C
Operating Temperature ..... -40° C to +85° C[1]
Lead Solder Temperature ..... 260° C for 10 s
(1.6 mm below seating plane)
Average Forward Input Current — I_F ..... 10 mA
Peak Transient Input Current — I_F 1A
($\leq$1 μs Pulse Width, 300 pps)
Reverse Input Voltage 5V
Supply Voltage — V_{CC} ..... 0.0V min., 20V max.
Three State Enable Voltage
— V_E ..... -0.5V min., 20V max.
Output Voltage — V_O ..... -0.5V min., 20V max.
Total Package Power
Dissipation — P ..... 210 mW[1]
Average Output Current — I_O ..... 25 mA

Electrical Characteristics

For 0° C $\leq T_A$[1] $\leq$ 85° C, 4.5 V $\leq V_{CC} \leq$ 20 V, 1.6 mA $\leq I_{F(ON)} \leq$ 5 mA, 2.0 V $\leq V_{EH} \leq$ 20 V, 0.0 V $\leq V_{EL} \leq$ 0.8 V, 0 mA $\leq I_{F(OFF)} \leq$ 0.1 mA. All Typicals at T_A = 25° C, V_{CC} = 5V, $I_{F(ON)}$ = 3 mA unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions		Figure	Note
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 6.4 mA (4 TTL Loads)		2	
Logic High Output Voltage	V_{OH}	2.4	*		Volts	I_{OH} = -2.6 mA	*$V_{OH} = V_{CC} - 2.1V$	3	
Output Leakage Current ($V_{OUT} > V_{CC}$)	I_{OHH}			100	μA	V_O = 5.5V	I_F = 5 mA		
				500	μA	V_O = 20V	V_{CC} = 4.5V		
Logic High Enable Voltage	V_{EH}	2.0			Volts				
Logic Low Enable Voltage	V_{EL}			0.8	Volts				
Logic High Enable Current	I_{EH}			20	μA	V_{EN} = 2.7V			
				100	μA	V_{EN} = 5.5V			
			.004	250	μA	V_{EN} = 20V			
Logic Low Enable Current	I_{EL}			-0.32	mA	V_{EN} = 0.4V			
Logic Low Supply Current	I_{CCL}		4.5	6.0	mA	V_{CC} = 5.5V	I_F = 0 mA		
			5.25	7.5	mA	V_{CC} = 20V	V_E = Don't Care		
Logic High Supply Current	I_{CCH}		2.7	4.5	mA	V_{CC} = 5.5V	I_F = 5 mA,		
			3.1	6.0	mA	V_{CC} = 20V	V_E = Don't Care		
High Impedance State Output Current	I_{OZL}			-20	μA	V_O = 0.4V	V_{EN} = 2V, I_F = 5 mA		
	I_{OZH}			20	μA	V_O = 2.4V	V_{EN} = 2V, I_F = 0		
				100	μA	V_O = 5.5V			
				500	μA	V_O = 20V			
Logic Low Short Circuit Output Current	I_{OSL}	25			mA	$V_O = V_{CC}$ = 5.5V	I_F = 0 mA		2
		40			mA	$V_O = V_{CC}$ = 20V			
Logic High Short Circuit Output Current	I_{OSH}	-10			mA	V_{CC} = 5.5V	I_F = 5 mA, V_O = GND		2
		-25			mA	V_{CC} = 20V			
Input Current Hysteresis	I_{HYS}		0.12		mA	V_{CC} = 5V		4	
Input Forward Voltage	V_F		1.5	1.70	Volts	I_F = 5 mA, T_A = 25° C		5	
Input Reverse Breakdown Voltage	V_R	5			Volts	I_R= 10μA, T_A =25° C			
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		-1.7		mV/° C	I_F = 5 mA			
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O}=3kV dc, T_A=25° C			3, 7
OPT. 010	V_{ISO}	2500			V_{RMS}	RH $\leq$ 50%, t = 1 min.			8
Input-Output Resistance	R_{I-O}		10^{12}		ohms	V_{I-O} = 500 VDC			3
Input-Output Capacitance	C_{I-O}		0.6		pF	f = 1 MHz, V_{I-O} = 0 VDC			3
Input Capacitance	C_{IN}		60		pF	f = 1 MHz, V_F = 0V, Pins 2 and 3			

Switching Characteristics

For $0°C \le T_A^{[1]} \le 85°C$, $4.5V \le V_{CC} \le 20V$, $1.6\ mA \le I_{F(ON)} \le 5\ mA$, $0.0\ mA \le I_{F(OFF)} \le 0.1\ mA$. All Typicals at $T_A = 25°C$, $V_{CC} = 5V$, $I_{F(ON)} = 3\ mA$ unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Propagation Delay Time to Logic Low Output Level	t_{PHL}		210		ns	Without Peaking Capacitor	6,7	4,5
			160	300		With Peaking Capacitor		
Propagation Delay Time to Logic High Output Level	t_{PLH}		170		ns	Without Peaking Capacitor	6,7	4,5
			115	300		With Peaking Capacitor		
Output Enable Time to Logic High	t_{PZH}		25		ns		8,10	
Output Enable Time to Logic Low	t_{PZL}		28		ns		8,9	
Output Disable Time from Logic High	t_{PHZ}		105		ns		8,10	
Output Disable Time from Logic Low	t_{PLZ}		60		ns		8,9	
Output Rise Time (10-90%)	t_r		55		ns		6,11	
Output Fall Time (90-10%)	t_f		15		ns		6,11	
Logic High Common Mode Transient Immunity	$\|CM_H\|$	1000	10,000		V/μs	$T_A = 25°C$, $I_F = 1.6\ mA$, $V_{CM} = 50\ V$	12,13	6
Logic Low Common Mode Transient Immunity	$\|CM_L\|$	1000	10,000		V/μs	$T_A = 25°C$, $I_F = 0$, $V_{CM} = 50\ V$	12,13	6

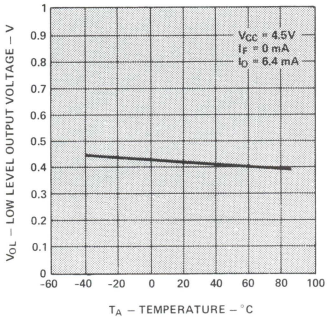


Figure 2. Typical Logic Low Output Voltage vs. Temperature

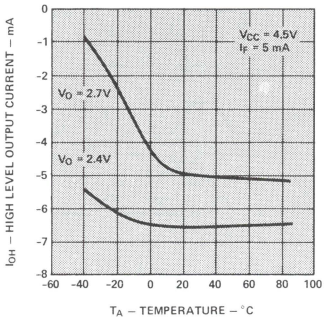


Figure 3. Typical Logic High Output Current vs. Temperature

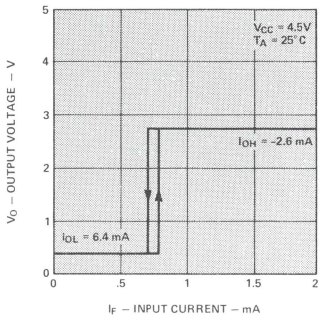


Figure 4. Output Voltage vs. Forward Input Current

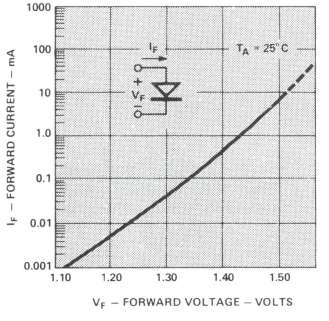


Figure 5. Typical Input Diode Forward Characteristic

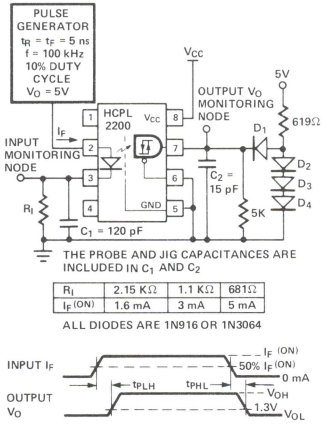


Figure 6. Test Circuit for t_{PLH}, t_{PHL}, t_r, and t_f

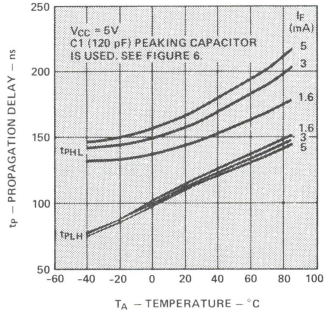


Figure 7. Typical Propagation Delays vs. Temperature

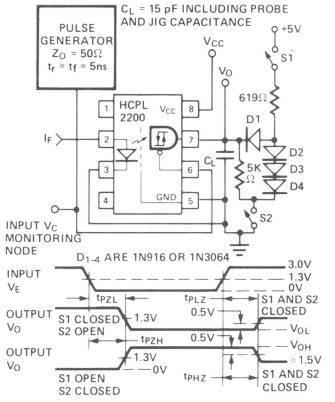


Figure 8. Test Circuit for t_{PHZ}, t_{PZH}, t_{PLZ}, and t_{PZL}

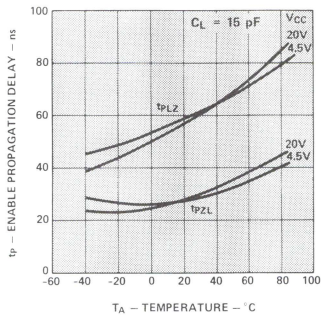


Figure 9. Typical Logic Low Enable Propagation Delay vs. Temperature

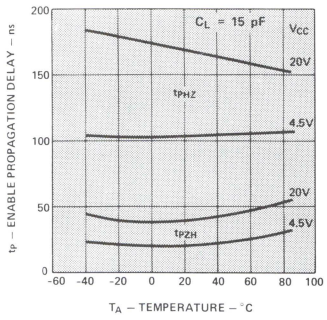


Figure 10. Typical Logic High Enable Propagation Delay vs. Temperature

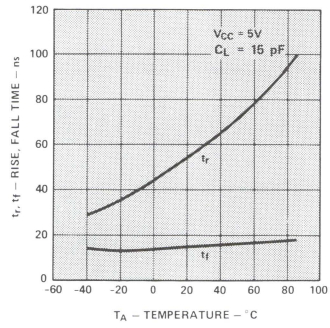


Figure 11. Typical Rise, Fall Time vs. Temperature

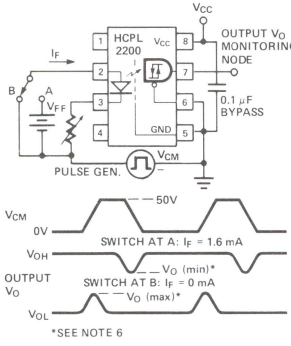


Figure 12. Test Circuit for Common Mode Transient Immunity and Typical Waveforms

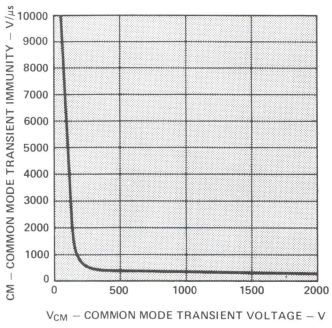


Figure 13. Typical Common Mode Transient Immunity vs. Common Mode Transient Amplitude

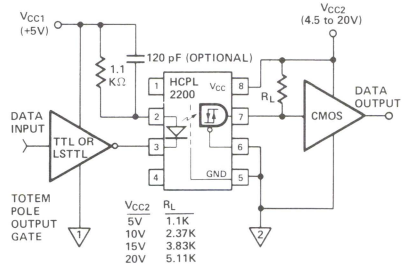


Figure 14. LSTTL to CMOS Interface Circuit

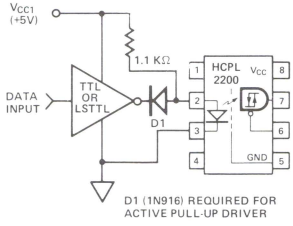


Figure 15. Recommended LED Drive Circuit

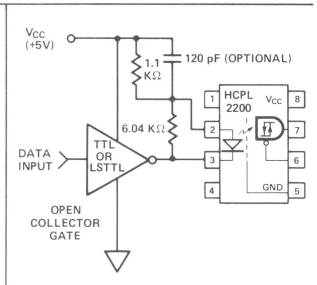


Figure 16. Series LED Drive with Open Collector Gate (6.04 KΩ Resistor Shunts I_{OH} from the LED)

The 120 pF capacitor may be omitted in applications where 500 ns propagation delay is sufficient.

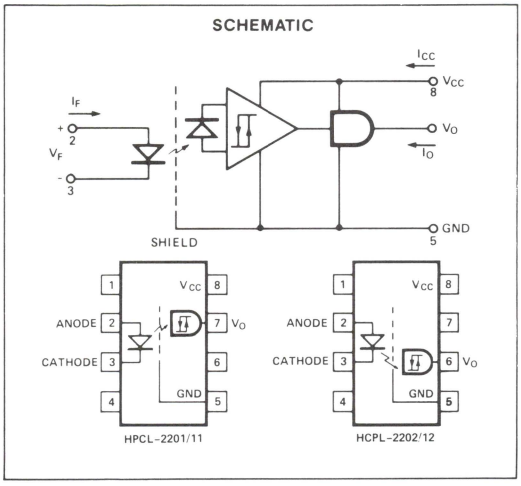
Notes:

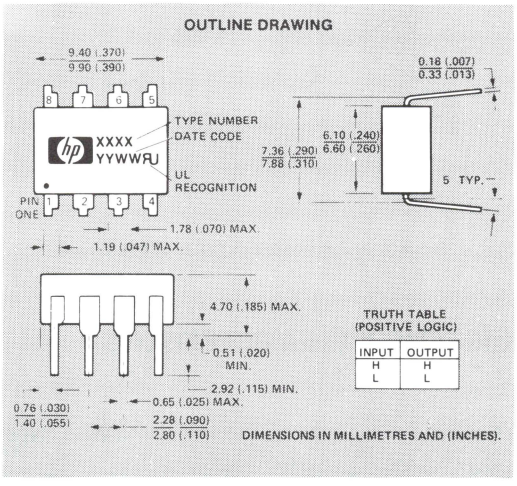
1. Derate total package power dissipation, P, linearly above 70° C free air temperature at a rate of 4.5 mW/° C.
2. Duration of output short circuit time should not exceed 10 ms.
3. Device considered a two terminal device: pins 1, 2, 3 and 4 shorted together, and pins 5, 6, 7 and 8 shorted together.
4. The t_{PLH} propagation delay is measured from the 50% point on the leading edge of the input pulse to the 1.3V point on the leading edge of the output pulse. The t_{PHL} propagation delay is measured from the 50% point on the trailing edge of the input pulse to the 1.3V point on the trailing edge of the output pulse.
5. When the peaking capacitor is omitted, propagation delay times may increase by 100 ns.
6. CM_L is the maximum rate of rise of the common mode voltage that can be sustained with the output voltage in the logic low state (V_O < 0.8V). CM_H is the maximum rate of fall of the common mode voltage that can be sustained with the output voltage in the logic high state (V_O > 2.0V).
7. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
8. See Option 010 data sheet for more information.

HEWLETT PACKARD

VERY HIGH CMR, WIDE V_{CC} LOGIC GATE OPTOCOUPLER

HCPL-2201
HCPL-2202
HCPL-2211
HCPL-2212





Features

- **VERY HIGH COMMON MODE REJECTION, 5 KV/μsec AT 300 V GUARANTEED (HCPL-2211/12)**
- **WIDE V_{CC} RANGE (4.5 TO 20 VOLTS)**
- **300 ns PROPAGATION DELAY GUARANTEED OVER THE FULL TEMPERATURE RANGE**
- **5 MBAUD TYPICAL DATA RATE**
- **LOW INPUT CURRENT (1.6 mA)**
- **TOTEM POLE OUTPUT (NO PULLUP RESISTOR REQUIRED)**
- **GUARANTEED PERFORMANCE FROM -40° C TO +85° C**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010)**

Applications

- **ISOLATION OF HIGH SPEED LOGIC SYSTEMS**
- **COMPUTER-PERIPHERAL INTERFACES**
- **MICROPROCESSOR SYSTEM INTERFACES**
- **GROUND LOOP ELIMINATION**
- **PULSE TRANSFORMER REPLACEMENT**
- **HIGH SPEED LINE RECEIVER**

Description

The HCPL-2201/02/11/12 are single-channel, optically-coupled logic gates. The detectors have totem pole output stages and optical receiver input stages with built-in Schmitt triggers to provide logic-compatible waveforms, eliminating the need for additional waveshaping.

A superior internal shield on the HCPL-2211/12 guarantees common mode transient immunity of 5,000 V/μsec at a common mode voltage of 300 volts.

The electrical and switching characteristics of the HCPL-2201/02/11/12 are guaranteed from -40° C to +85° C and a V_{CC} from 4.5 volts to 20 volts. Low I_F and wide V_{CC} range allow compatibility with TTL, LSTTL, and CMOS logic and result in lower power consumption compared to other high speed couplers. Logic signals are transmitted with a typical propagation delay of 150 nsec.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.5	20	Volts
Forward Input Current	$I_{F(ON)}$	2.2*	5	mA
Forward Input Voltage	$V_{F(OFF)}$	—	0.8	Volts
Operating Temperature	T_A	-40	85	°C
Fan Out	N		4	TTL Loads

*2.2 mA condition includes an LED degradation guardband. Initial switching threshold is 1.6 mA or less. See Figure 11.

OPTOCOUPLERS

Recommended Circuit Design

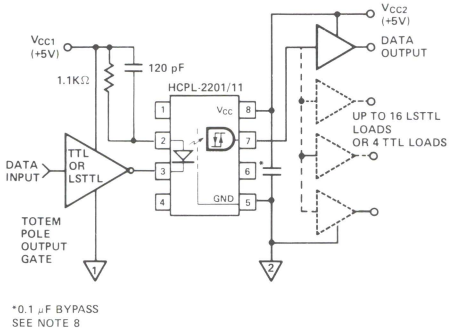


Figure 1. Recommended LSTTL to LSTTL Circuit

Absolute Maximum Ratings

(No Derating Required up to 70°C)

Storage Temperature ..... -55°C to +125°C

Operating Temperature ..... -40°C to +85°C

Lead Solder Temperature ..... 260°C for 10 s
(1.6 mm below seating plane)

Average Forward Input Current — I_F ..... 10 mA

Peak Transient Input Current — I_F ..... 1 A
(≤1 μs Pulse Width, 300 pps)

Reverse Input Voltage ..... 5 V

Supply Voltage — V_{CC} ..... 0.0 V min., 20 V max.

Output Voltage — V_O ..... -0.5 V min., 20 V max.

Total Package Power Dissipation — P ..... 210 mW[1]

Average Output Current — I_O ..... 25 mA

Electrical Characteristics

$-40°C \le T_A \le 85°C$, $4.5\ V \le V_{CC} \le 20\ V$, $1.6\ mA \le I_{F(ON)} \le 5\ mA$, $0\ V \le V_{F(OFF)} \le 0.8\ V$, unless otherwise specified.
All Typicals at $T_A = 25°C$.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions		Figure	Note
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 6.4 mA (4 TTL Loads)		2, 4	
Logic High Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -2.6 mA	V_{CC} = 4.5 V	3, 4, 8	
		2.7				I_{OH} = -0.4 mA			
Output Leakage Current ($V_{OUT} > V_{CC}$)	I_{OHH}			100	μA	V_O = 5.5 V	I_F = 5 mA, V_{CC} = 4.5 V		
				500	μA	V_O = 20 V			
Logic Low Supply Current	I_{CCL}		3.7	6.0	mA	V_{CC} = 5.5 V	V_F = 0 V		
			4.3	7.0	mA	V_{CC} = 20 V			
Logic High Supply Current	I_{CCH}		2.4	4.0	mA	V_{CC} = 5.5 V	I_F = 5 mA		
			2.7	5.0	mA	V_{CC} = 20 V			
Logic Low Short Circuit Output Current	I_{OSL}	15			mA	$V_O = V_{CC}$ = 5.5 V	V_F = 0 V		2
		20			mA	$V_O = V_{CC}$ = 20 V			
Logic High Short Circuit Output Current	I_{OSH}	-10			mA	V_{CC} = 5.5 V	I_F = 5 mA, V_O = GND		2
		-20			mA	V_{CC} = 20 V			
Input Forward Voltage	V_F		1.5	1.70	Volts	I_F = 5 mA, T_A = 25°C		5	
Input Reverse Breakdown Voltage	V_R	5			Volts	I_R = 10 μA, T_A = 25°C			
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		-1.7		mV/°C	I_F = 5 mA			
Input-Output Insulation	I_{I-O}			1	μA	V_{I-O} = 3000 VDC, T_A = 25°C, t = 5 s, Relative Humidity = 45%			3, 6
OPTION 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50%, t = 1 min.			7
Input-Output Resistance	R_{I-O}		10^{12}		ohms	V_{I-O} = 500 VDC			3
Input-Output Capacitance	C_{I-O}		0.6		pF	f = 1 MHz, V_{I-O} = 0 VDC			3
Input Capacitance	C_{IN}		60		pF	f = 1 MHz, V_F = 0 V, Pins 2 and 3			

Switching Characteristics $-40°C \le T_A \le 85°C$, $4.5\ V \le V_{CC} \le 20\ V$, $1.6\ mA \le I_{F(ON)} \le 5\ mA$, $0\ V \le V_{F(OFF)} \le 0.8\ V$. All Typicals at $T_A = 25°C$, $V_{CC} = 5\ V$, $I_{F(ON)} = 3\ mA$ unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Propagation Delay Time to Logic Low Output Level	t_{PHL}		150		ns	Without Peaking Capacitor	6, 7	4
			150	300		With Peaking Capacitor		
Propagation Delay Time to Logic High Output Level	t_{PLH}		110		ns	Without Peaking Capacitor	6, 7	4
			90	300		With Peaking Capacitor		
Output Rise Time (10-90%)	t_r		30		ns		6, 9	
Output Fall Time (90-10%)	t_f		7		ns		6, 9	

Parameter	Symbol	Device	Min.	Units	Test Conditions		Figure	Note
Logic High Common Mode Transient Immunity	$\|CM_H\|$	HCPL-2201 HCPL-2202	1,000	V/μs	$\|Vcm\| = 50\ V$	$I_F = 1.6\ mA$ $V_{CC} = 5\ V$ $T_A = 25°C$	10	5
		HCPL-2211 HCPL-2212	5,000	V/μs	$\|Vcm\| = 300\ V$			
Logic Low Common Mode Transient Immunity	$\|CM_L\|$	HCPL-2201 HCPL-2202	1,000	V/μs	$\|Vcm\| = 50\ V$	$V_F = 0\ V$ $V_{CC} = 5\ V$ $T_A = 25°C$	10	5
		HCPL-2211 HCPL-2212	5,000	V/μs	$\|Vcm\| = 300\ V$			

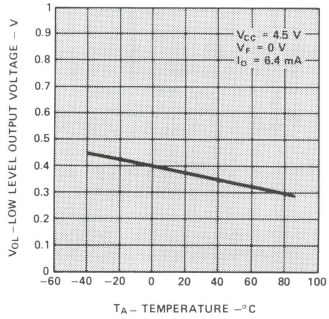


Figure 2. Typical Logic Low Output Voltage vs. Temperature

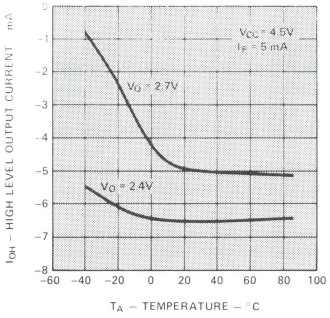


Figure 3. Typical Logic High Output Current vs. Temperature

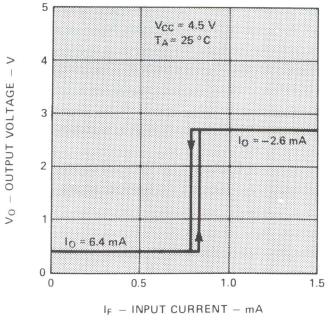


Figure 4. Output Voltage vs. Forward Input Current

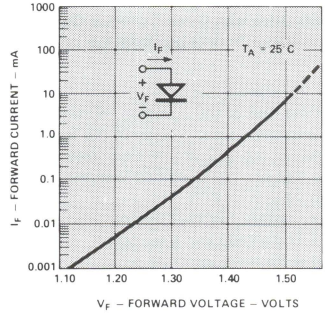


Figure 5. Typical Input Diode Forward Characteristic

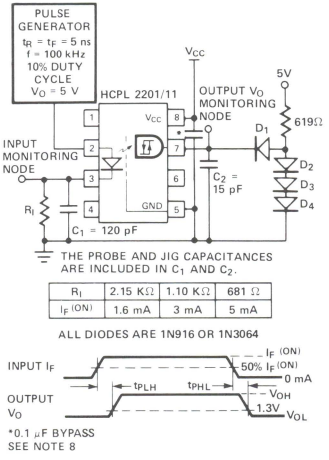


Figure 6. Circuit for t_{PLH}, t_{PHL}, t_r, t_f

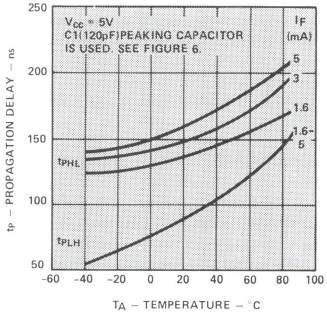


Figure 7. Typical Propagation Delays vs. Temperature

OPTOCOUPLERS

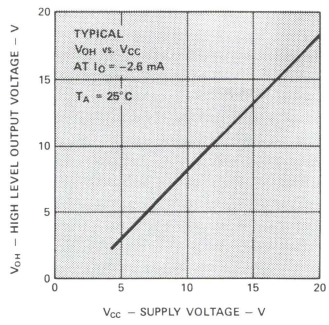


Figure 8. Typical Logic High Output Voltage vs. Supply Voltage

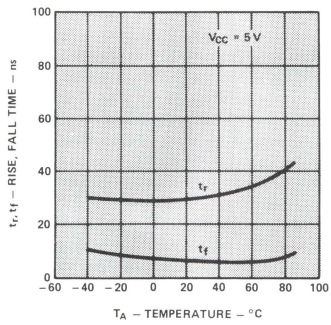


Figure 9. Typical Rise, Fall Time vs. Temperature

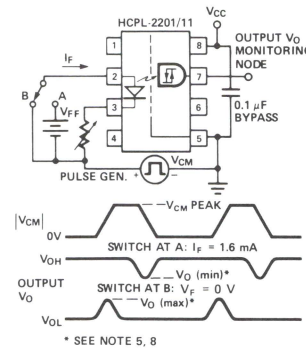


Figure 10. Test Circuit for Common Mode Transient Immunity and Typical Waveforms

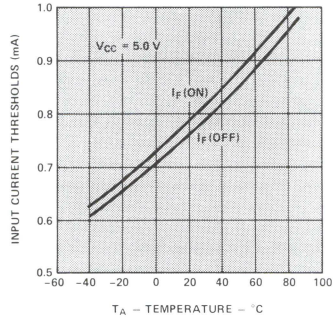


Figure 11. Typical Input Threshold Current vs. Temperature

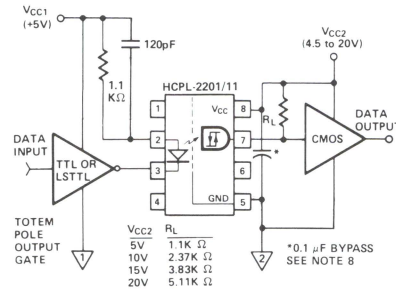


Figure 12. LSTTL to CMOS Interface Circuit

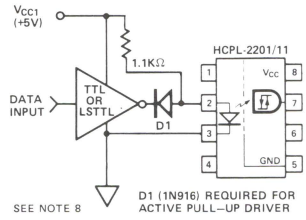


Figure 13. Alternative LED Drive Circuit

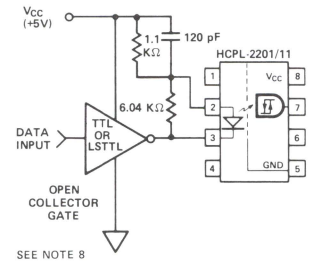


Figure 14. Series LED Drive with Open Collector Gate (6.04 KΩ Resistor Shunts I_{OH} from the LED)

Notes:

1. Derate total package power dissipation, P, linearly above 70°C free air temperature at a rate of 4.5 mW/°C.
2. Duration of output short circuit time should not exceed 10 ms.
3. Device considered a two terminal device: pins 1, 2, 3 and 4 shorted together, and pins 5, 6, 7 and 8 shorted together.
4. The t_{PLH} propagation delay is measured from the 50% point on the leading edge of the input pulse to the 1.3 V point on the leading edge of the output pulse. The t_{PHL} propagation delay is measured from the 50% point on the trailing edge of the input pulse to the 1.3 V point on the trailing edge of the output pulse.
5. CM_L is the maximum slew rate of the common mode voltage that can be sustained with the output voltage in the logic low state. V_O < 0.8 V. CM_H is the maximum slew rate of the common mode voltage that can be sustained with the output voltage in the logic high state V_O > 2.0 V.
6. This is a proof test to validate the UL 220 Vac rating. This rating is equally validated by a 2500 Vac 1 sec test.
7. See Option 010 data sheet for more information.
8. For HCPL-2202/12, V_O is on pin 6

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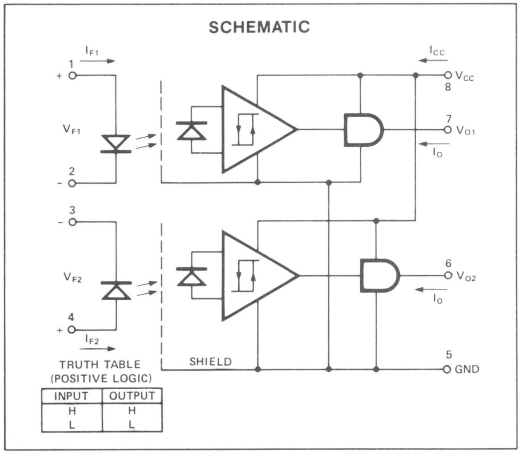
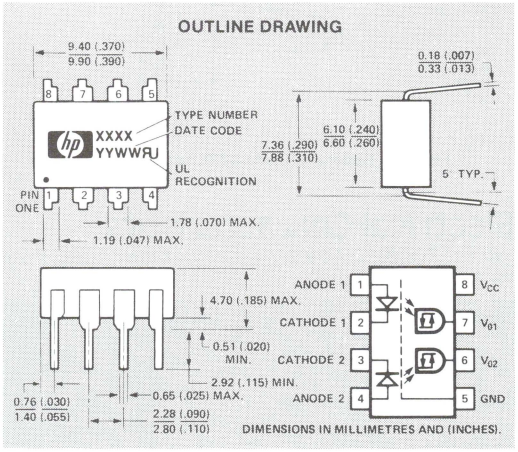
VERY HIGH CMR, WIDE V_{CC} DUAL LOGIC GATE OPTOCOUPLER

HCPL-2231
HCPL-2232





Features

- VERY HIGH COMMON MODE REJECTION 5 KV/μsec AT 300 V GUARANTEED (HCPL-2232)
- WIDE V_{CC} RANGE (4.5 TO 20 VOLTS)
- 300 ns PROPAGATION DELAY GUARANTEED OVER THE FULL TEMPERATURE RANGE
- 5 MBAUD TYPICAL DATA RATE
- LOW INPUT CURRENT (1.8 mA)
- TOTEM POLE OUTPUT (NO PULLUP RESISTOR REQUIRED)
- GUARANTEED PERFORMANCE FROM -40°C TO +85°C
- RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010)
- HCPL-5230/1 COMPATIBILITY

Applications

- ISOLATION OF HIGH SPEED LOGIC SYSTEMS
- COMPUTER-PERIPHERAL INTERFACES
- MICROPROCESSOR SYSTEM INTERFACES
- GROUND LOOP ELIMINATION
- PULSE TRANSFORMER REPLACEMENT
- HIGH SPEED LINE RECEIVER

Description

The HCPL-2231/2 are dual-channel, optically-coupled logic gates. The detectors have totem pole output stages and optical receiver input stages with built-in Schmitt triggers to provide logic compatible waveforms, eliminating the need for additional waveshaping.

A superior internal shield on the HCPL-2232 guarantees common mode transient immunity of 5,000 V/μsec at a common mode voltage of 300 volts.

The electrical and switching characteristics of the HCPL-2231/2 are guaranteed from -40°C to +85°C and a V_{CC} from 4.5 volts to 20 volts. Low I_F and wide V_{CC} range allow compatibility with TTL, LSTTL, and CMOS logic and result in lower power consumption compared to other high speed couplers. Logic signals are transmitted with a typical propagation delay of 150 nsec.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.5	20	Volts
Input Current (High)	$I_{F(ON)}$	2.5*	5	mA
Input Voltage (Low)	$V_{F(OFF)}$	—	0.8	Volts
Operating Temperature	T_A	-40	85	°C
Fan Out per Channel	N		4	TTL Loads

*2.5 mA condition includes an LED degradation guardband. Initial switching threshold is 1.8 mA or less. See Figure 12.

OPTOCOUPLERS

Recommended Circuit Design

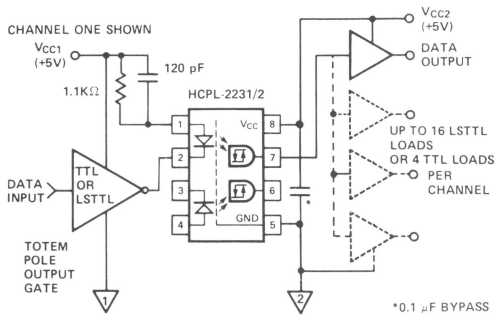


Figure 1. Recommended LSTTL to LSTTL Circuit

Absolute Maximum Ratings

Storage Temperature ..... -55°C to +125°C
Operating Temperature ..... -40°C to +85°C
Lead Solder Temperature ..... 260°C for 10 s
(1.6 mm below seating plane)
Average Forward Input Current — I_F ..... 10 mA[1]
Peak Transient Input Current — I_F ..... 1 A[1]
(≤1 μs Pulse Width, 300 pps)
Reverse Input Voltage ..... 5 V[1]
Supply Voltage — V_{CC} ..... 0.0 V min., 20 V max.
Output Voltage — V_O ..... -0.5 V min., 20 V max.[1]
Total Package Power Dissipation ..... 294 mW
Output Power Dissipation — P_O per Channel ..... Fig. 8
Average Output Current — I_O per Channel ..... 25 mA

Electrical Characteristics

$-40°C \le T_A \le 85°C$, $4.5\ V \le V_{CC} \le 20\ V$, $1.8\ mA \le I_{F(ON)} \le 5\ mA$, $0\ V \le V_{F(OFF)} \le 0.8\ V$, unless otherwise specified.
All Typicals at $T_A = 25°C$.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions		Figure	Note
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 6.4 mA (4 TTL Loads)		2, 4	1
Logic High Output Voltage	V_{OH}	2.4 2.7			Volts	I_{OH} = -2.6 mA I_{OH} = -0.4 mA	V_{CC} = 4.5 V	3, 4, 9	1
Output Leakage Current ($V_{OUT} > V_{CC}$)	I_{OHH}			100	μA	V_O = 5.5 V	I_F = 5 mA V_{CC} = 4.5 V		1
				500	μA	V_O = 20 V			
Logic Low Supply Current	I_{CCL}		7.4	12.0	mA	V_{CC} = 5.5 V	V_F = 0 V		
			8.6	14.0	mA	V_{CC} = 20 V			
Logic High Supply Current	I_{CCH}		4.8	8.0	mA	V_{CC} = 5.5 V	I_F = 5 mA		
			5.4	10.0	mA	V_{CC} = 20 V			
Logic Low Short Circuit Output Current	I_{OSL}	15			mA	$V_O = V_{CC}$ = 5.5 V	V_F = 0 V		1, 2
		20			mA	$V_O = V_{CC}$ = 20 V			
Logic High Short Circuit Output Current	I_{OSH}	-10			mA	V_{CC} = 5.5 V	I_F = 5 mA V_O = GND		1, 2
		-20			mA	V_{CC} = 20 V			
Input Forward Voltage	V_F		1.5	1.7	Volts	I_F = 5 mA, T_A = 25°C		5	1
Input Reverse Breakdown Voltage	V_R	5			Volts	I_R = 10 μA, T_A = 25°C			1
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		-1.7		mV/°C	I_F = 5 mA			
Input-Output Insulation	I_{I-O}			1	μA	V_{I-O} = 3000 VDC T_A = 25°C, t = 5 s Relative Humidity = 45%			3, 6
OPTION 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50%, t = 1 min.			7
Input-Output Resistance	R_{I-O}		10^{12}		ohms	V_{I-O} = 500 VDC			3
Input-Output Capacitance	C_{I-O}		0.6		pF	f = 1 MHz, V_{I-O} = 0 VDC			3
Input Capacitance	C_{IN}		60		pF	f = 1 MHz, V_F = 0 V			1
Input-Input Insulation Leakage Current	I_{I-I}		0.005		μA	Relative Humidity = 45% t = 5 s, V_{I-I} = 500 V			8
Resistance (Input-Input)	R_{I-I}		10^{11}		Ω	V_{I-I} = 500 V			8
Capacitance (Input-Input)	C_{I-I}		0.25		pF	f = 1 MHz			8

Switching Characteristics $-40°C \le T_A \le 85°C$, $4.5\ V \le V_{CC} \le 20\ V$, $1.8\ mA \le I_{F(ON)} \le 5\ mA$, $0 \le V_{F(OFF)} \le 0.8\ V$. All Typicals at $T_A = 25°C$, $V_{CC} = 5\ V$, $I_{F(ON)} = 3\ mA$ unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Propagation Delay Time to Logic Low Output Level	t_{PHL}		150		ns	Without Peaking Capacitor	6, 7	1, 4
			150	300		With Peaking Capacitor		
Propagation Delay Time to Logic High Output Level	t_{PLH}		110		ns	Without Peaking Capacitor	6, 7	1, 4
			90	300		With Peaking Capacitor		
Output Rise Time (10-90%)	t_r		30		ns		6, 10	1
Output Fall Time (90-10%)	t_f		7		ns		6, 10	1

Parameter	Symbol	Device	Min.	Units	Test Conditions		Figure	Note
Logic High Common Mode Transient Immunity	$\|CM_H\|$	HCPL-2231	1,000	V/μs	$\|Vcm\| = 50\ V$	$I_F = 1.8\ mA$, $V_{CC} = 5\ V$, $T_A = 25°C$	11	1, 5
		HCPL-2232	5,000	V/μs	$\|Vcm\| = 300\ V$			
Logic Low Common Mode Transient Immunity	$\|CM_L\|$	HCPL-2231	1,000	V/μs	$\|Vcm\| = 50\ V$	$V_F = 0\ V$, $V_{CC} = 5\ V$, $T_A = 25°C$	11	1, 5
		HCPL-2232	5,000	V/μs	$\|Vcm\| = 300\ V$			

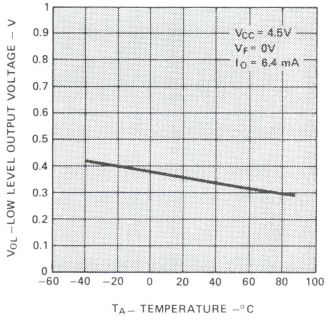


Figure 2. Typical Logic Low Output Voltage vs. Temperature

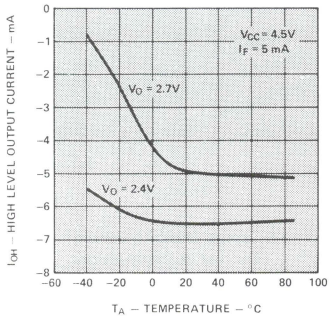


Figure 3. Typical Logic High Output Current vs. Temperature

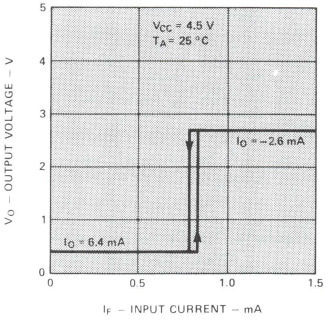


Figure 4. Output Voltage vs. Forward Input Current

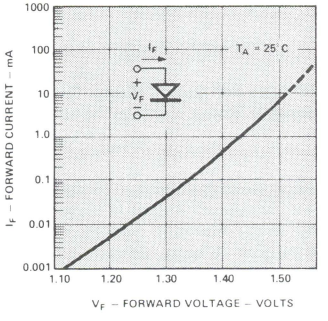
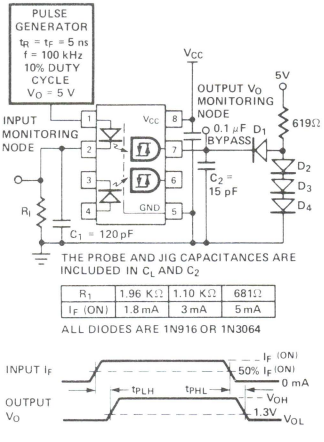


Figure 5. Typical Input Diode Forward Characteristic



Note: Channel one shown.

Figure 6. Circuit for t_{PLH}, t_{PHL}, t_r, t_f

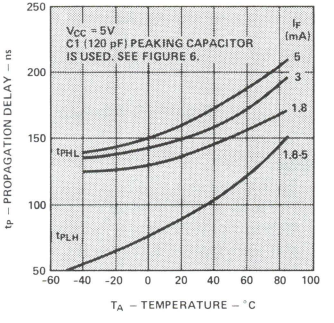


Figure 7. Typical Propagation Delays vs. Temperature

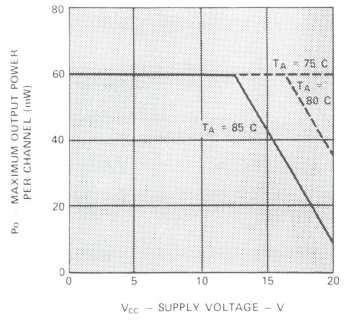


Figure 8. Maximum Output Power per Channel vs. Supply Voltage

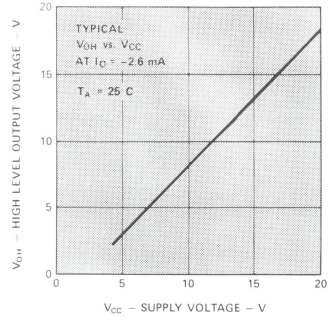


Figure 9. Typical Logic High Output Voltage vs. Supply Voltage

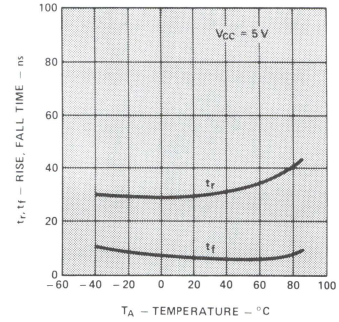


Figure 10. Typical Rise, Fall Time vs. Temperature

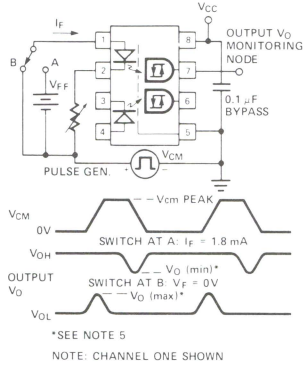


Figure 11. Test Circuit for Common Mode Transient Immunity and Typical Waveforms

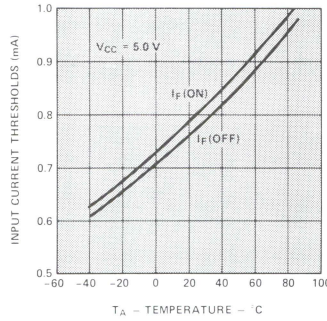


Figure 12. Typical Input Threshold Current vs. Temperature

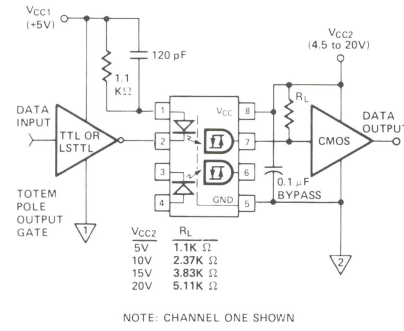


Figure 13. LSTTL to CMOS Interface Circuit

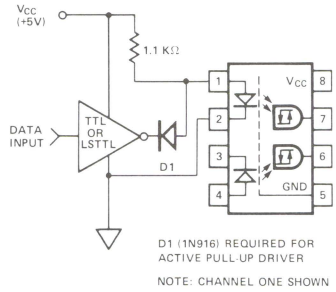


Figure 14. Alternate LED Drive Circuit

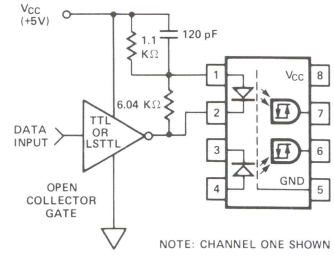


Figure 15. Series LED Drive with Open Collector Gate (6.04 KΩ Resistor Shunts I_{OH} from the LED)

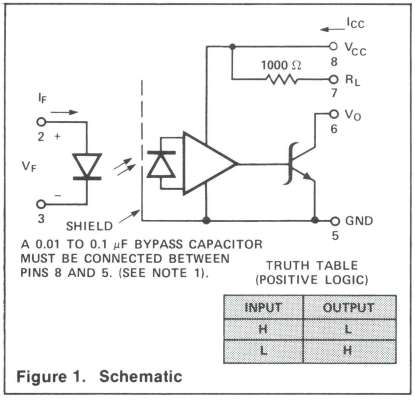
Notes:

1. Each channel.
2. Duration of output short circuit time should not exceed 10 ms.
3. Device considered a two terminal device: pins 1, 2, 3 and 4 shorted together, and pins 5, 6, 7 and 8 shorted together.
4. The t_{PLH} propagation delay is measured from the 50% point on the leading edge of the input pulse to the 1.3 V point on the leading edge of the output pulse. The t_{PHL} propagation delay is measured from the 50% point on the trailing edge of the input pulse to the 1.3 V point on the trailing edge of the output pulse.
5. CM_L is the maximum slew rate of the common mode voltage that can be sustained with the output voltage in the logic low state. V_O < 0.8 V. CM_H is the maximum slew rate of the common mode voltage that can be sustained with the output voltage in the logic high state V_O > 2.0 V.
6. This is a proof test to validate the UL 220 Vac rating. This rating is equally validated by a 2500 Vac 1 sec test.
7. See Option 010 data sheet for more information.
8. Measured between pins 1 and 2, shorted together, and pins 3 and 4, shorted together.

HEWLETT PACKARD

LOW INPUT CURRENT HIGH SPEED OPTOCOUPLER

HCPL-2300

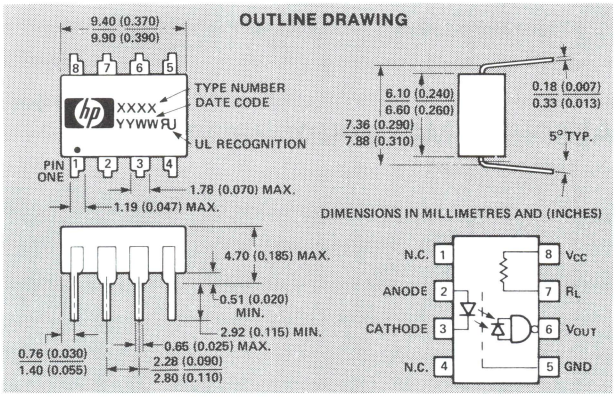


A 0.01 TO 0.1 μF BYPASS CAPACITOR MUST BE CONNECTED BETWEEN PINS 8 AND 5. (SEE NOTE 1).

TRUTH TABLE (POSITIVE LOGIC)

INPUT	OUTPUT
H	L
L	H

Figure 1. Schematic



Features

- **GUARANTEED LOW THRESHOLDS: I_F = 0.5 mA, $V_F \leq$ 1.5 V**
- **HIGH SPEED: GUARANTEED 5 MBd OVER TEMPERATURE**
- **VERSATILE: COMPATIBLE WITH TTL, LSTTL AND CMOS**
- **MORE EFFICIENT 820 nm AlGaAs IRED**
- **INTERNAL SHIELD FOR GUARANTEED COMMON MODE REJECTION**
- **SCHOTTKY CLAMPED, OPEN COLLECTOR OUTPUT WITH OPTIONAL INTEGRATED PULL-UP RESISTOR**
- **STATIC AND DYNAMIC PERFORMANCE GUARANTEED FROM -40°C to 85°C**
- **SPECIAL SELECTION FOR LOW FORWARD CURRENT APPLICATIONS ($I_F \geq$ 150 μA)**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**

Applications

- **GROUND LOOP ELIMINATION**
- **COMPUTER-PERIPHERAL INTERFACES**
- **LEVEL SHIFTING**
- **MICROPROCESSOR SYSTEM INTERFACES**
- **DIGITAL ISOLATION FOR A/D, D/A CONVERSION**
- **RS-232-C INTERFACE**
- **HIGH SPEED, LONG DISTANCE ISOLATED LINE RECEIVER**

Description

The HCPL-2300 optocoupler combines an 820 nm AlGaAs photon emitting diode with an integrated high gain photon detector. This combination of Hewlett-Packard designed and manufactured semiconductor devices brings high performance capabilities to designers of isloted logic and data communication circuits.

The low current, high speed AlGaAs emitter manufactured with a unique diffused junction, has the virtue of fast rise and fall ties at low drive currents. The HCPL-2300 has a typical propagation delay of 120 ns at 0.5 mA forward current. With special selection, the device can achieve 80 ns propagation delay at 150 μA. Figure 6 illustrates the propagation delay vs. input current characteristic. These unique characteristics enable this device to be used in an RS-232-C interface with ground loop isolation and improved common mode rejection. As a line receiver, the HCPL-2300 will operate over longer line lengths for a given data rate because of lower I_F and V_F specifications.

The output of the shielded integrated detector circuit is an open collector Schottky clamped transistor. The shield, which shunts capacitively coupled common mode noise to ground, provides a guaranteed transient immunity specification of 100 V/μs. The output circuit includes an optional integrated 1000 Ohm pull-up resistor for the open collector. This gives designers the flexibility to use the internal resistor for pull-up to five volt logic or to use an external resistor for 18 volt CMOS logic.

The Electrical and Switching Characteristics of the HCPL-2300 are guaranteed over a temperature range of -40° C to 85° C. This data sheet will allow users of the HCPL-2300 to confidently implement all necessary static and dynamic performance requirements which may be subjected to a broad range of operating environments.

Recommended Operating Conditions

		Sym.	Min.	Max.	Units
Input Voltage, Low Level		V_{FL}	-2.5	0.8	V
Input Current High Level	0° C to 85° C	I_{FH}	0.5	1.0	mA
	-40° C to 85° C		0.5	0.75	
Supply Voltage, Output		V_{CC}	4.75	5.25	V
Fan Out (TTL Load)		N		5	
Operating Temperature		T_A	-40	85	°C

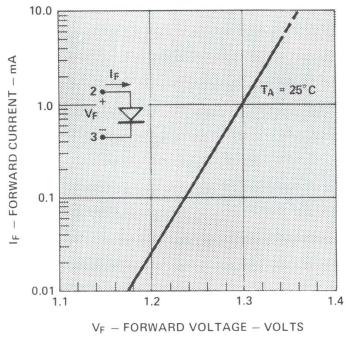


Figure 2. Typical Input Diode Forward Characteristic.

Absolute Maximum Ratings

(No derating required)

Parameter	Symbol	Min.	Max.	Units	Reference
Storage Temperature	T_S	-55	125	°C	
Operating Temperature	T_A	-40	85	°C	
Lead Solder Temperature	260° C for 10 s. (1.6 mm below seating plane)				
Average Forward Input Current	I_F		5	mA	See Note 2
Reverse Input Voltage	V_R		4.5	V	
Supply Voltage	V_{CC}	0.0	7.0	V	
Pull-up Resistor Voltage	V_{RL}	-0.5	V_{CC}	V	
Output Collector Current	I_O	-25	25	mA	
Input Power Dissipation	P_I		10	mW	
Output Collector Power Dissipation	P_O		40	mW	
Output Collector Voltage	V_O	-0.5	18	V	

Electrical Characteristics

For -40° C ≤ T_A ≤ 85° C, 4.75 V ≤ V_{CC} ≤ 5.25 V, V_{FL} ≤ 0.8 V, unless otherwise specified.
All typicals at T_A = 25° C, V_{CC} = 5 V, unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
High Level Output Current	I_{OH}		0.05	250	μA	V_F = 0.8 V, V_O = 18 V	4	
Low Level Output Voltage	V_{OL}		0.4	0.5	V	I_F = 0.5 mA I_{OL} (Sinking) = 8 mA	3	
High Level Supply Current	I_{CCH}		4.0	6.3	mA	I_F = 0 mA, V_{CC} = 5.25 V		
Low Level Supply Current	I_{CCL}		6.2	10.0	mA	I_F = 1.0 mA, V_{CC} = 5.25 V		
Input Forward Voltage	V_F	1.0	1.3	1.5	V	I_F = 1.0 mA, T_A = 25° C	2	
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		-1.6		mV/° C	I_F = 1.0 mA		
Input Reverse Breakdown Voltage	BV_R	4.5			V	I_R = 10 μA, T_A = 25° C		
Input Capacitance	C_{IN}		18		pF	V_F = 0 V, f = 1 MHz		
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 3 kV dc, T_A = 25° C		3, 9
OPT 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50% t = 1 MIN		10
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	V_{I-O} = 500 V		3
Capacitance (Input-Output)	C_{I-O}		0.6		pF	f = 1 MHz		3
Internal Pull-up Resistor	R_L	680	1000	1700	Ohms	T_A = 25°C	8	

Switching Characteristics

For -40° C ≤ T_A ≤ 85° C, 0.5 mA ≤ I_{FH} ≤ 0.75 mA;
For 0° C ≤ T_A ≤ 85° C, 0.5 mA ≤ I_{FH} ≤ 1.0 mA; With 4.75 V ≤ V_{CC} ≤ 5.25 V, V_{FL} ≤ 0.8 V, unless otherwise specified.
All typicals at T_A = 25° C, V_{CC} = 5 V, I_{FH} = 0.625 mA, unless otherwise specified.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Propagation Delay Time to Logic High Output Level	t_{PLH}		95		ns	C_P = 0 pF	5, 6, 8	4, 8
			85	160		C_P = 20 pF	5, 8	
Propagation Delay Time to Logic Low Output Level	t_{PHL}		110		ns	C_P = 0 pF	5, 6, 8	5, 8
			35	200		C_P = 20 pF	5, 8	
Output Rise Time (10-90%)	t_r		40		ns	C_P = 20 pF	7, 8	8
Output Fall Time (90-10%)	t_f		20		ns			
Common Mode Transient Immunity at High Output Level	$\|CM_H\|$	100	400		V/μs	V_{CM} = 50 V (peak), V_O (min.) = 2 V, R_L = 560Ω, I_F = 0 mA	9, 10	6
Common Mode Transient Immunity at Low Output Level	$\|CM_L\|$	100	400		V/μs	V_{CM} = 50 V (peak), V_O (max.) = 0.8 V, R_L = 560Ω, I_F = 0.5 mA	9, 10	7

(See page 5-35 for Notes)

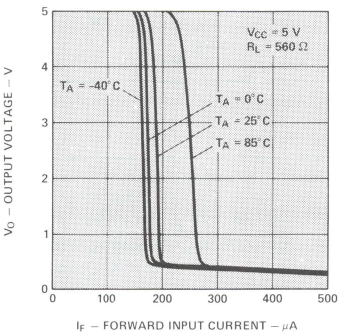


Figure 3. Typical Output Voltage vs. Forward Input Current vs. Temperature.

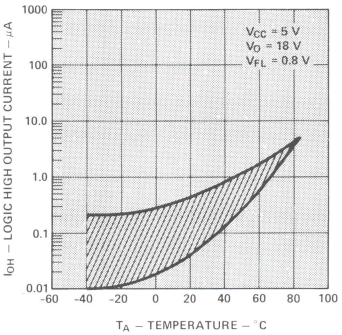


Figure 4. Typical Logic High Output Current vs. Temperature.

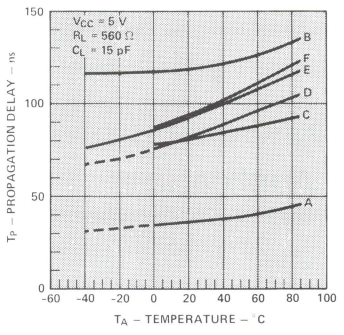


Figure 5. Typical Propagation Delay vs. Temperature and Forward Current With and Without Application of a Peaking Capacitor.

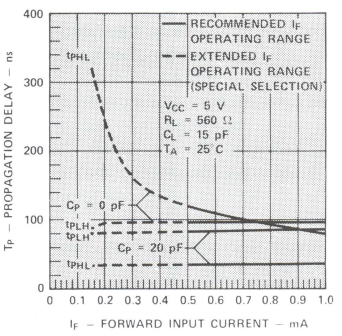


Figure 6. Typical Propagation Delay vs. Forward Current.

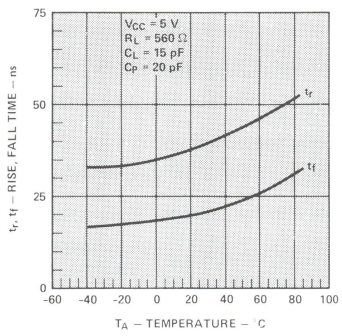


Figure 7. Typical Rise, Fall Time vs. Temperature.

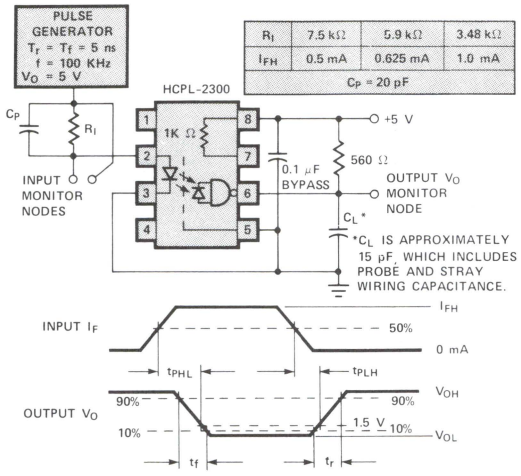


Figure 8. Test Circuit for t_{PHL}, t_{PLH}, t_r and t_f.

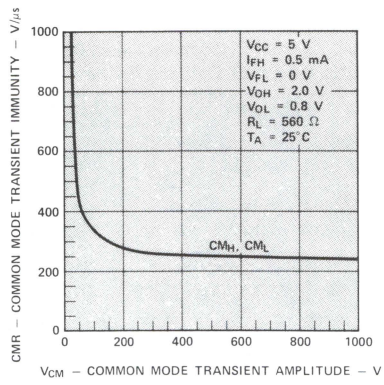
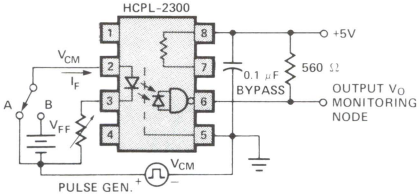


Figure 9. Typical Common Mode Transient Immunity vs. Common Mode Transient Amplitude.



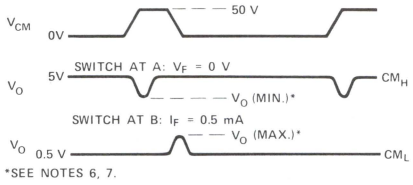


Figure 10. Test Circuit for Common Mode Transient Immunity and Typical Waveforms.

Applications

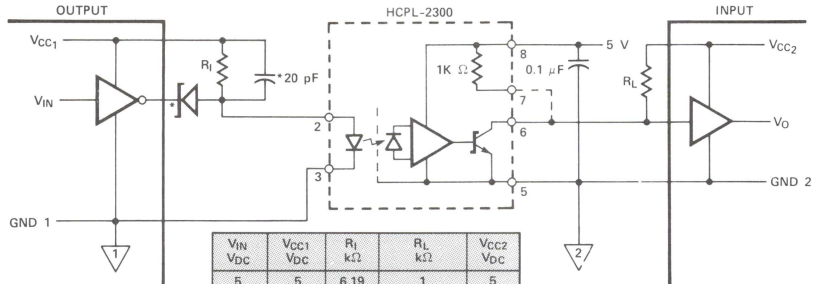
The HCPL-2300 optocoupler has the unique combination of low 0.5 mA LED operating drive current at a 5 MBd speed performance. Low power supply current requirement of 10 mA maximum and the ability to provide isolation between logic systems fulfills numerous applications ranging from logic level translations, line receiver and party line receiver applications, microprocessor I/O port isolation, etc. The open collector output allows for wired-OR arrangement. Specific interface circuits are illustrated in Figures 11 through 18 with corresponding component values, performance data and recommended layout.

For -40° C to 85° C operating temperature range, a mid range LED forward current (I_F) of 0.625 mA is recommended in order to prevent overdriving the integrated circuit detector due to increased LED efficiency at temperatures between 0° C and -40° C. For narrower temperature range of 0° C to 85° C, a suggested operating LED current of 0.75 mA is recommended for the mid range operating point and for minimal propagation delay skew. A peaking capacitance of 20 pF in parallel with the current limiting resistor for the LED shortens t_{PHL} by approximately 33% and t_{PLH} by 13%. Maintaining LED forward voltage (V_F) below 0.8 V will guarantee that the HCPL-2300 output is off.

The recommended shunt drive technique for TTL/LSTTL/CMOS of Figure 11 provides for optimal speed performance, no leakage current path through the LED, and reduced common mode influences associated with series switching of a "floating" LED. Alternate series drive techniques with either an active CMOS inverter or an open collector TTL/LSTTL inverter are illustrated in Figures 12 and 13 respectively. Open collector leakage current of 250 μA has been compensated by the 3.16K Ohms resistor (Figure 13) at the expense of twice the operating forward current.

An application of the HCPL-2300 as an unbalanced line receiver for use in long line twisted wire pair communication links is shown in Figure 14. Low LED I_F and V_F allow longer line length, higher speed and multiple stations on the line in comparison to higher I_F, V_F optocouplers. Greater speed performance along with nearly infinite common mode immunity are achieved via the balanced split phase circuit of Figure 15. Basic balanced (differential) line receiver can be accomplished with one HCPL-2300 in Figure 15, but with a typical 400 V/μs common mode immunity. Data rate versus distance for both the above unbalanced and balanced line receiver applications are compared in Figure 16. The RS-232-C interface circuit of Figure 17 provides guaranteed minimum common mode immunity of 100 V/μs while maintaining the 2:1 dynamic range of I_F.

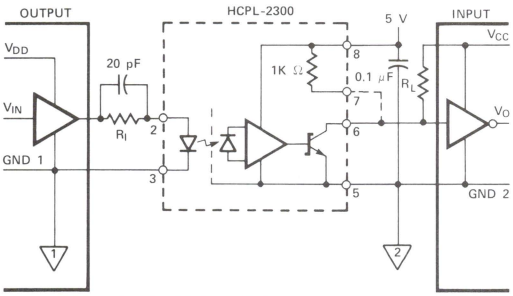
A recommended layout for use with an internal 1000 Ohms resistor or an external pull-up resistor and required V_{CC} bypass capacitor is given in Figure 18. V_{CC1} is used with an external pull-up resistor for output voltage levels (V0) greater than or equal to 5 V. As illustrated in Figure 18, an optional V_{CC} and GND trace can be located between the input and the output leads of the HCPL-2300 to provide additional noise immunity at the compromise of insulation capability (VI-0).



V_{IN} V_{DC}	V_{CC1} V_{DC}	R_I kΩ	R_L kΩ	V_{CC2} V_{DC}
5	5	6.19	1 (INTERNAL)	5
10	10	14.7	2.37	10
15	15	21.5	3.16	15

*SCHOTTKY DIODE (HP 5082-2800, OR EQUIVALENT) AND 20 pF CAPACITOR ARE NOT REQUIRED FOR UNITS WITH OPEN COLLECTOR OUTPUT.

Figure 11. Recommended Shunt Drive Circuit for Interfacing Between TTL/LSTTL/CMOS Logic Systems.



V_{IN} V_{DC}	V_{DD} V_{DC}	R_I kΩ	R_L kΩ	V_{CC} V_{DC}
5	5	5.11	1 (INTERNAL)	5
10	10	13.3	2.37	10
15	15	19.6	3.16	15

Figure 12. Active CMOS Series Drive Circuit.

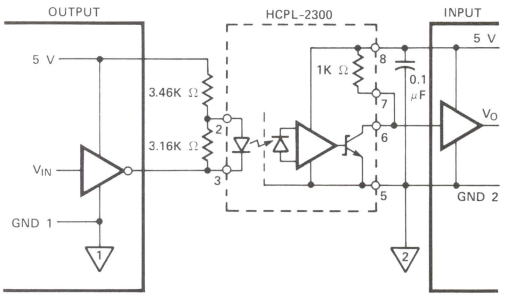


Figure 13. Series Drive from Open Collector TTL/LSTTL Units.

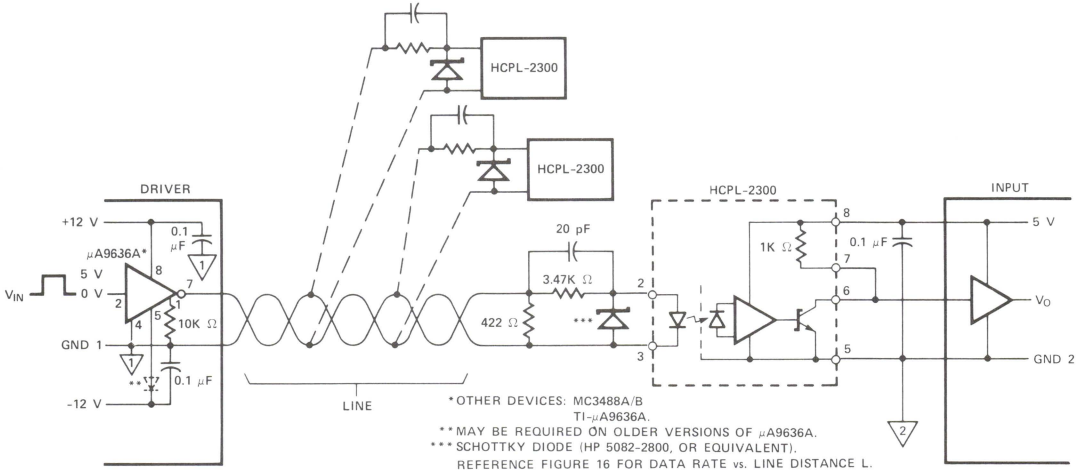
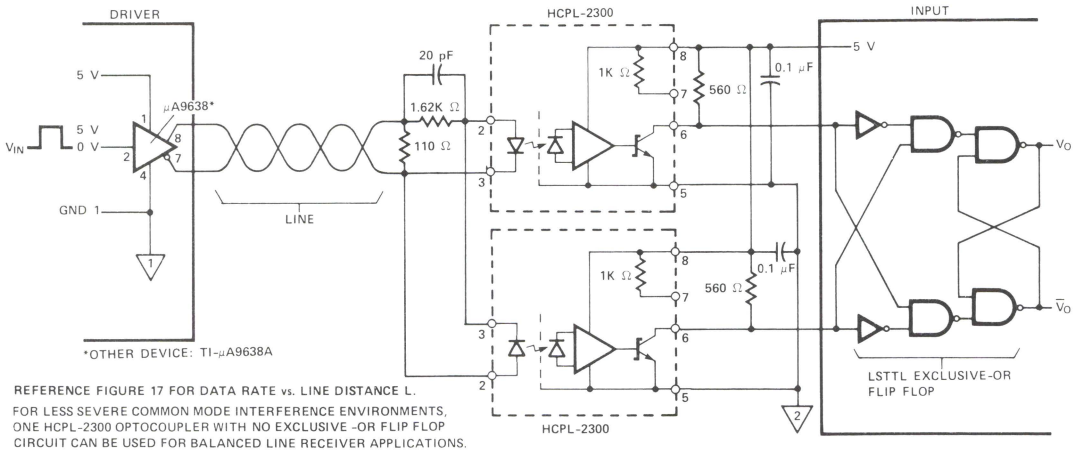


Figure 14. Application of HCPL-2300 as Isolated, Unbalanced Line Receiver(s).



REFERENCE FIGURE 17 FOR DATA RATE vs. LINE DISTANCE L.

FOR LESS SEVERE COMMON MODE INTERFERENCE ENVIRONMENTS, ONE HCPL-2300 OPTOCOUPLER WITH NO EXCLUSIVE -OR FLIP FLOP CIRCUIT CAN BE USED FOR BALANCED LINE RECEIVER APPLICATIONS.

$V_O = V_{IN}$.

Figure 16. Application of Two HCPL-2300 Units Operating as an Isolated, High Speed, Balanced, Split Phase Line Receiver with Significantly Enhanced Common Mode Immunity.

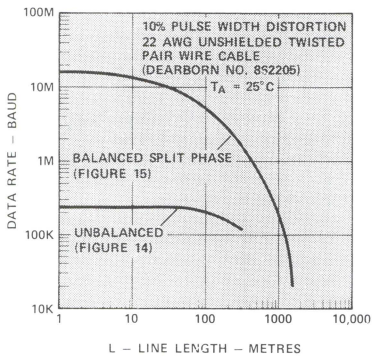


Figure 17. Typical Point to Point Data Rate vs. Length of Line for Unbalanced (Figure 15) and Balanced (Figure 16) Line Receivers using HCPL-2300 Optocouplers.

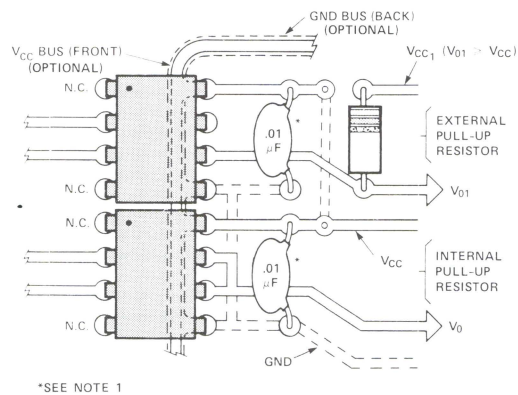


Figure 19. Recommended Printed Circuit Board Layout.

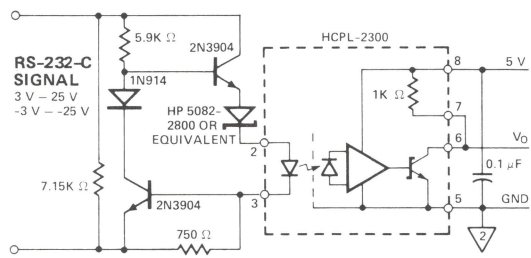


Figure 18. RS-232-C Interface Circuit with HCPL-2300. $0°C < T_A < 85°C$.

NOTES:

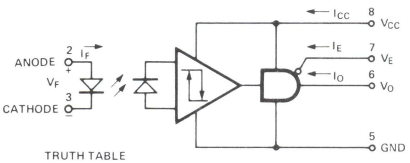
1. Bypassing of the power supply line is required with a 0.01 μF ceramic disc capacitor adjacent to each optocoupler as illustrated in Figure 19. The power supply bus for the optocoupler(s) should be separate from the bus for any active loads, otherwise a larger value of bypass capacitor (up to 0.1 μF) may be needed to suppress regenerative feedback via the power supply.
2. Peaking circuits may produce transient input currents up to 100 mA, 500 ns maximum pulse width, provided average current does not exceed 5 mA.
3. Device considered a two terminal device: pins 1, 2, 3 and 4 shorted together, and pins 5, 6, 7 and 8 shorted together.
4. The t_{PLH} propagation delay is measured from the 50% point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
5. The t_{PHL} propagation delay is measured from the 50% point on the leading edge of the input pulse to the 1.5 V point on the leading edge of the output pulse.
6. CM_H is the maximum tolerable rate of rise of the common mode voltage to assure that the output will remain in a high logic state (i.e., $V_{OUT} > 2.0$ V).
7. CM_L is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state (i.e., $V_{OUT} < 0.8$ V).
8. C_P is the peaking capacitance. Refer to test circuit in Figure 9.
9. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
10. See Option 010 data sheet for more information

HEWLETT PACKARD

20 M BAUD HIGH CMR LOGIC GATE OPTOCOUPLER

HCPL-2400
HCPL-2411

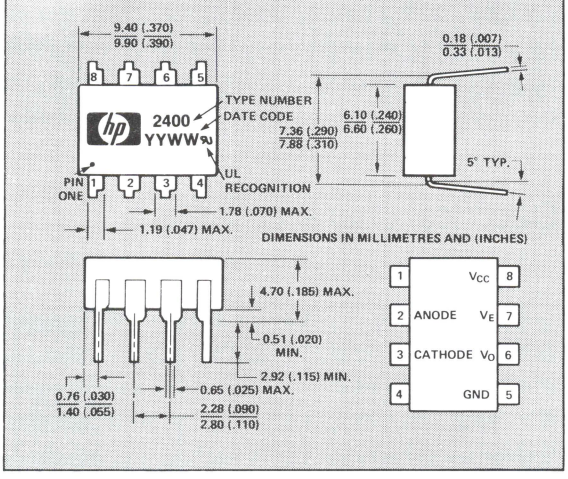
SCHEMATIC



TRUTH TABLE
(POSITIVE LOGIC)

INPUT	ENABLE	OUTPUT
H	L	L
L	L	H
H	H	Z
L	H	Z

OUTLINE DRAWING



Features

- HIGH SPEED: 40 MBd TYPICAL DATA RATE
- HIGH COMMON MODE REJECTION
- HCPL-2400 = 50 V_{CM}
- HCPL-2411 = 300 V_{CM}
- AC PERFORMANCE GUARANTEED OVER TEMPERATURE
- COMPATIBLE WITH TTL, STTL, LSTTL, AND HCMOS LOGIC FAMILIES
- NEW, HIGH SPEED AlGaAs EMITTER
- THREE STATE OUTPUT (NO PULL-UP RESISTOR REQUIRED)
- HIGH POWER SUPPLY NOISE IMMUNITY
- RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).
- HCPL-5400/1 COMPATIBILITY

Applications

- ISOLATION OF HIGH SPEED LOGIC SYSTEMS
- COMPUTER-PERIPHERAL INTERFACES
- ISOLATED BUS DRIVER (NETWORKING APPLICATIONS)
- SWITCHING POWER SUPPLIES
- GROUND LOOP ELIMINATION
- HIGH SPEED DISK DRIVE I/O
- DIGITAL ISOLATION FOR A/D, D/A CONVERSION
- PULSE TRANSFORMER REPLACEMENT

Description

The HCPL-2400/11 high speed optocouplers combine an 820 nm AlGaAs photon emitting diode with a high speed photon detector. This combination results in very high data rate capability and low input current. The three state output eliminates the need for a pull-up resistor and allows for direct drive of data buses. The hysteresis provides typically 0.25 mA of differential mode noise immunity and minimizes the potential for output signal chatter. Improved power supply rejection minimizes the need for special power supply bypassing precautions.

The electrical and switching characteristics of the HCPL-2400/11 are guaranteed over the temperature range of 0°C to 70°C.

The HCPL-2400/11 are compatible with TTL, STTL, LSTTL and HCMOS logic families. When Schottky type TTL devices (STTL) are used, a data rate performance of 20 MBd over temperature is guaranteed when using the application circuit of Figure 13. Typical data rates are 40 MBd.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.75	5.25	Volts
Input Current (High)	$I_{F\ (ON)}$	4	8	mA
Input Voltage (Low)	$V_{F\ (OFF)}$	—	0.8	Volts
Enable Voltage (Low)	V_{EL}	0	0.8	Volts
Enable Voltage (High)	V_{EH}	2.0	V_{CC}	Volts
Operating Temperature	T_A	0	70°	°C
Fan Out	N		5	TTL Loads

OPTOCOUPLERS

Absolute Maximum Ratings

(No derating required up to 85° C)

Parameter	Symbol	Min.	Max.	Units	Note
Storage Temperature	T_S	−55	125	°C	
Operating Temperature	T_A	0	85	°C	
Lead Solder Temperature	260° C for 10 s. (1.6 mm below seating plane)				
Average Forward Input Current	I_F		10.0	mA	
Peak Forward Input Current	I_{FPK}		20.0	mA	9
Reverse Input Voltage	V_R		3.0	V	
Supply Voltage	V_{CC}	0	7.0	V	
Three State Enable Voltage	V_E	−0.5	10.0	V	
Average Output Collector Current	I_O	−25.0	25.0	mA	
Output Collector Voltage	V_O	−0.5	10.0	V	
Output Collector Power Dissipation	P_O		40.0	mW	

Electrical Characteristics

For 0° C ≤ T_A ≤ 70° C, 4.75 V ≤ V_{CC} ≤ 5.25 V, 4 mA ≤ $I_{F(ON)}$ ≤ 8 mA, 2.0 V ≤ V_{EH} ≤ 5.25, 0 V ≤ V_{EL} ≤ 0.8 V, 0 V ≤ $V_{F(OFF)}$ ≤ 0.8 V except where noted. All Typicals at T_A = 25° C, V_{CC} = 5 V, $I_{F(ON)}$ = 5.0 mA, $V_{F(OFF)}$ = 0 V except where noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions		Figure	Note
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 8.0 mA (5 TTL Loads)		1	
Logic High Output Voltage	V_{OH}	2.4			Volts	I_{OH} = −4.0 mA		2	
Output Leakage Current	I_{OHH}			100	μA	V_O = 5.25 V	V_F = 0.8 V		
Logic High Enable Voltage	V_{EH}	2.0			Volts				
Logic Low Enable Voltage	V_{EL}			0.8	Volts				
Logic High Enable Current	I_{EH}			20	μA	V_E = 2.4 V			
				100	μA	V_E = 5.25 V			
Logic Low Enable Current	I_{EL}		−0.28	−0.4	mA	V_E = 0.4V			
Logic Low Supply Current	I_{CCL}		19	26	mA	V_{CC} = 5.25 V			
Logic High Supply Current	I_{CCH}		17	26	mA	V_E = 0 V			
High Impedance State Supply Current	I_{CCZ}		22	28	mA	V_{CC} = 5.25 V V_E = 5.25 V			
High Impedance State Output Current	I_{OZL}			20	μA	V_O = 0.4V	V_E = 2 V		
	I_{OZH}			20	μA	V_O = 2.4 V	V_E = 2 V		
	I_{OZH}			100	μA	V_O = 5.25 V			
Logic Low Short Circuit Output Current	I_{OSL}		52		mA	V_O = V_{CC} = 5.25 V	I_F = 8 mA		1
Logic High Short Circuit Output Current	I_{OSH}		−45		mA	V_{CC} = 5.25 V	I_F = 0 mA, V_O = GND		1
Input Current Hysteresis	I_{HYS}		0.25		mA	V_{CC} = 5 V		3	
Input Forward Voltage	V_F	1.1	1.3	1.5	Volts	I_F = 5 mA, T_A = 25° C		4	
Input Reverse Breakdown Voltage	V_R	3.0	5.0		Volts	I_R = 10 μA, T_A = 25° C			
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		−1.44		mV/° C	I_F = 5 mA		4	
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 3kVdc, T_A = 25° C			2, 8
Option 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50%, t = 1 min.			10
Input-Output Resistance	R_{I-O}		10^{12}		ohms	V_{I-O} = 500 VDC			2
Input-Output Capacitance	C_{I-O}		0.6		pF	f = 1 MHz, V_{I-O} = 0 V dc			2
Input Capacitance	C_{IN}		20		pF	f = 1 MHz, V_F = 0V, Pins 2 and 3			

Switching Characteristics

$0°C \le T_A \le 70°C$, $4.75\ V \le V_{CC} \le 5.25\ V$, $0.0\ V \le V_{EN} \le 0.8\ V$, $4\ mA \le I_F \le 8.0\ mA$. All Typicals $V_{CC} = 5\ V$, $T_A = 25°C$, $I_F = 5.0\ mA$ except where noted.

Parameter	Symbol		Min.	Typ.	Max.	Units	Test Conditions		Figure	Note
Propagation Delay Time to Logic Low Output Level	t_{PHL}				55	ns	$I_{F(ON)} = 7.0\ mA$		5, 6, 7	4
			15	33	60	ns			5, 6, 7	3
Propagation Delay Time to Logic High Output Level	t_{PLH}				55	ns	$I_{F(ON)} = 7.0\ mA$		5, 6, 7	4
			15	30	60	ns			5, 6, 7	3
Pulse Width Distortion	$\lvert t_{PHL} - t_{PLH} \rvert$			2	15	ns	$I_{F(ON)} = 7.0\ mA$		5, 8	4
				3	25	ns			5, 8	
Channel Distortion	Δt_{PHL}			8	25	ns			5	5
	Δt_{PLH}			8	25	ns			5	5
Output Rise Time	t_r			20		ns			5	
Output Fall Time	t_f			10		ns			5	
Output Enable Time to Logic High	t_{PZH}			15		ns			9, 10	
Output Enable Time to Logic Low	t_{PZL}			30		ns			9, 10	
Output Disable Time from Logic High	t_{PHZ}			20		ns			9, 10	
Output Disable Time from Logic Low	t_{PLZ}			15		ns			9, 10	
Logic High Common Mode Transient Immunity	$\lvert CM_H \rvert$	2400	1000	10,000		V/μs	$V_{CM} = 50\ V$	$T_A = 25°C$, $I_F = 0$	11, 12	6
		2411	1000			V/μs	$V_{CM} = 300\ V$			
Logic Low Common Mode Transient Immunity	$\lvert CM_L \rvert$	2400	1000	10,000		V/μs	$V_{CM} = 50\ V$	$T_A = 25°C$, $I_F = 4\ mA$	11, 12	6
		2411	1000			V/μs	$V_{CM} = 300\ V$			
Power Supply Noise Immunity	PSNI			0.5		V_{p-p}	$V_{CC} = 5.0\ V$, $48\ Hz \le F_{AC} \le 50\ MHz$			7

Notes:

1. Duration of output short circuit time not to exceed 10 ms.
2. Device considered a two terminal device: pins 1–4 shorted together, and pins 5–8 shorted together.
3. t_{PHL} propagation delay is measured from the 50% level on the rising edge of the input current pulse to the 1.5 V level on the falling edge of the output pulse. The t_{PLH} propagation delay is measured from the 50% level on the falling edge of the input current pulse to the 1.5 V level on the rising edge of the output pulse.
4. This specification simulates the worst case operating conditions of the HCPL-2400/11 over the recommended operating temperature and V_{CC} range with the suggested applications circuit of Figure 13.
5. Channel distortion describes the worst case variation of propagation delay from one part to another at identical operating conditions.
6. CM_H is the maximum slew rate of common mode voltage that can be sustained with the output voltage in the logic high state ($V_{O(MIN)} > 2.0\ V$). CM_L is the maximum slew rate of common mode voltage that can be sustained with the output voltage in the logic low state ($V_{O(MAX)} < 0.8\ V$).
7. Power Supply Noise Immunity is the peak to peak amplitude of the ac ripple voltage on the V_{CC} line that the device will withstand and still remain in the desired logic state. For desired logic high state, $V_{OH(MIN)} > 2.0\ V$, and for desired logic low state, $V_{OL(MAX)} < 0.8$ volts.
8. This is a proof test. This rating is equally validated by a 2500 V ac, 1 second test per UL E55 361.
9. Peak Forward Input Current pulse width < 50 μs at 1 KHz maximum repetition rate.
10. See Option 010 data sheet for more information.

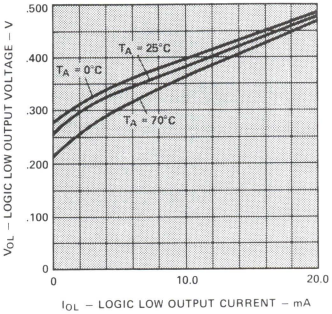


Figure 1. Typical Logic Low Output Voltage vs. Logic Low Output Current

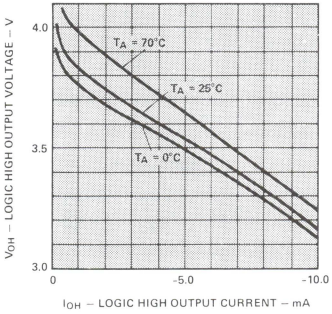


Figure 2. Typical Logic High Output Voltage vs. Logic High Output Current

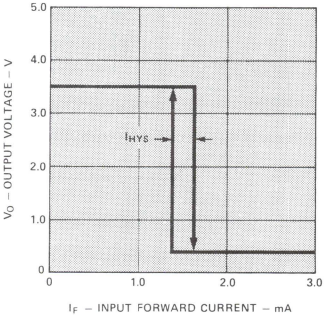


Figure 3. Typical Output Voltage vs. Input Forward Current

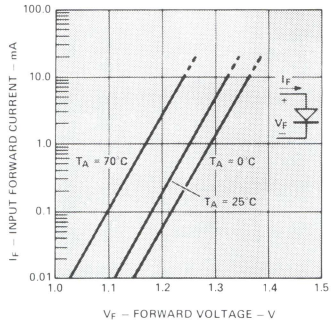


Figure 4. Typical Diode Input Forward Current Characteristic

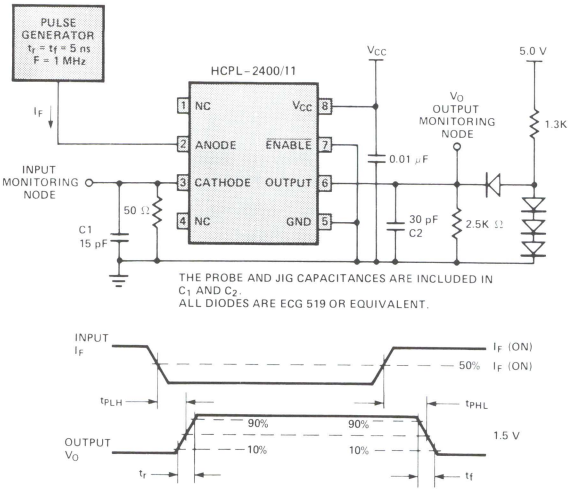


Figure 5. Test Circuit for t_{PLH}, t_{PHL}, t_r, and t_f

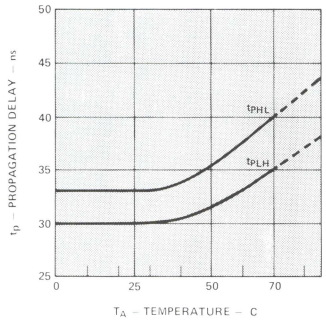


Figure 6. Typical Propagation Delay vs. Ambient Temperature

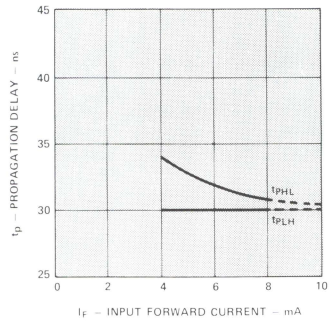


Figure 7. Typical Propagation Delay vs. Input Forward Current

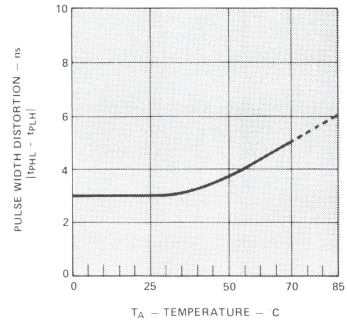
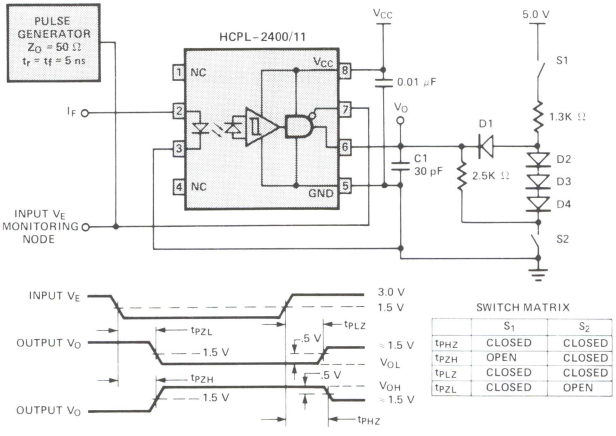


Figure 8. Typical Pulse Width Distortion vs. Ambient Temperature



	S_1	S_2
t_{PHZ}	CLOSED	CLOSED
t_{PZH}	OPEN	CLOSED
t_{PLZ}	CLOSED	CLOSED
t_{PZL}	CLOSED	OPEN

Figure 9. Test Circuit for t_{PHZ}, t_{PZH}, t_{PLZ} and t_{PZL}.

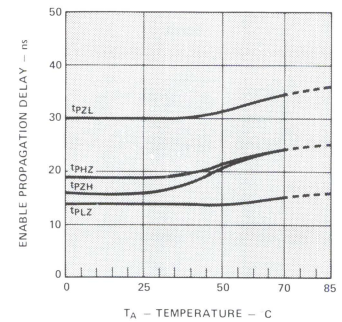
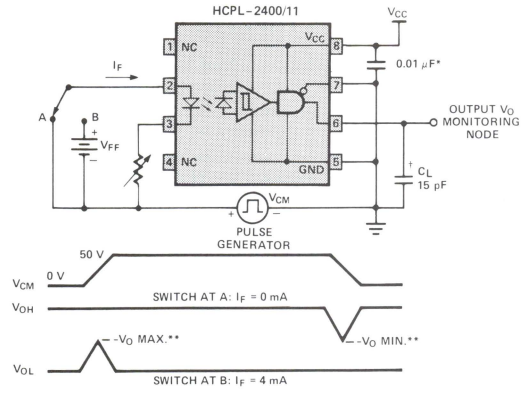


Figure 10. Typical Enable Propagation Delay vs. Ambient Temperature



*MUST BE LOCATED < 1 cm FROM DEVICE UNDER TEST.
**SEE NOTE 6.
† C_L IS APPROXIMATELY 15 pF, WHICH INCLUDES PROBE AND STRAY WIRING CAPACITANCE.

Figure 11. Test Diagram for Common Mode Transient Immunity and Typical Waveforms

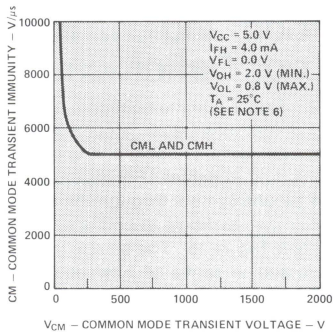


Figure 12. Typical Common Mode Transient Immunity vs. Common Mode Transient Voltage

Applications

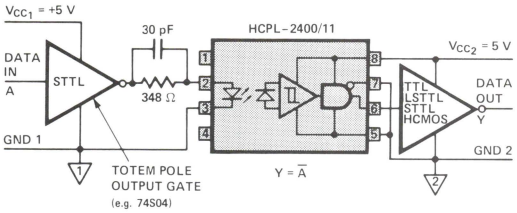


Figure 13. Recommended 20 MBd HCPL-2400/11 Interface Circuit

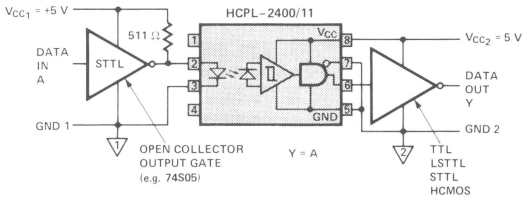


Figure 14. Alternative HCPL-2400/11 Interface Circuit

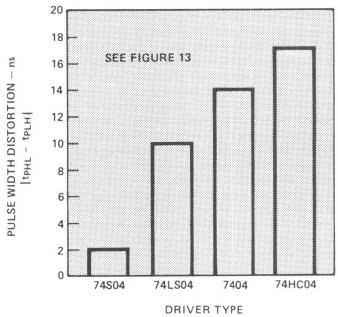


Figure 15. Typical Pulse Width Distortion vs. Input Driver Logic Family

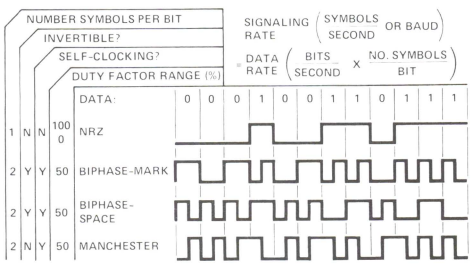


Figure 16. Modulation Code Selections

Data Rate, Pulse-Width Distortion, and Channel Distortion Definitions

In the world of data communications, a bit is defined as the smallest unit of information a computer operates with. A bit is either a Logic 1 or Logic 0, and is interpreted by a number of coding schemes. For example, a bit can be represented by one symbol through the use of NRZ code, or can contain two symbols in codes such as Biphase or Manchester (see Figure 16). The bit rate capability of a system is expressed in terms of bits/second (b/s) and the symbol rate is expressed in terms of Baud (symbols/second). For NRZ code, the bit rate capability equals the Baud capability because the code contains one symbol per bit of information. For Biphase and Manchester codes, the bit rate capability is equal to one half of the Baud capability, because there are two symbols per bit.

Propagation delay is a figure of merit which describes the finite amount of time required for a system to translate information from input to output when shifting logic levels. Propagation delay from low to high (t_{PLH}) specifies the amount of time required for a system's output to change from a Logic 0 to a Logic 1, when given a stimulus at the input. Propagation delay from high to low (t_{PHL}) specifies the amount of time required for a system's output to change from a Logic 1 to a Logic 0, when given a stimulus at the input (see Figure 5).

When t_{PLH} and t_{PHL} differ in value, pulse width distortion results. Pulse width distortion is defined as $|t_{PHL}-t_{PLH}|$ and determines the maximum data rate capability of a distortion-limited system. Maximum pulse width distortion on the order of 20–30% is typically used when specifying the maximum data rate capabilities of systems. The exact figure depends on the particular application (RS-232, PCM, T-1, etc.).

Channel distortion, (Δt_{PHL}, Δt_{PLH}), describes the worst case variation of propagation delay from device to device at identical operating conditions. Propagation delays tend to shift as operating conditions change, and channel distortion specifies the uniformity of that shift. Specifying a maximum value for channel distortion is helpful in parallel data transmission applications where the synchronization of signals on the parallel lines is important.

The HCPL-2400/11 optocouplers offer the advantages of specified propagation delay (t_{PLH}, t_{PHL}), pulse-width distortion ($|t_{PLH}-t_{PHL}|$), and channel distortion (Δt_{PLH}, Δt_{PHL}) over temperature, input forward current, and power supply voltage ranges.

Applications Circuits

A recommended application circuit for high speed operation is shown in Figure 13. Due to the fast current switching capabilities of Schottky family TTL logic (74STTL), data rates of 20 MBd are achievable from 0 to 70°C. the 74S04 totem-pole driver sources current to series-drive the input of the HCPL-2400/11 optocoupler. The 348Ω resistor limits the LED forward current. The 30 pF speed-up capacitor assists in the turn-on and turn-off of the LED, increasing the data rate capability of the circuit. On the output side, the following logic can be directly driven by the output of the HCPL-2400/11 since a pull-up resistor is not required. If desired, a non-inverting buffer may be substituted on either the input or the output side to change the circuit function from Y = A to Y = A. This circuit satisfies all recommended operating conditions.

An alternative circuit is shown in Figure 14, which utilizes a 74S05 open-collector inverter to shunt-drive the HCPL-2400/11 optocoupler. This circuit also satisfies all recommended operating conditions.

The HCPL-2400/11 optocouplers are compatible with other logic familes, such as TTL, LSTTL, and HCMOS. However, the output drive capabilities of Schottky family devices greatly exceed those associated with TTL, LSTTL, and HCMOS logic families, and are recommended in high data rate (20 MBd) applications where fast drive current transitions are required to operate the HCPL-2400/11 with minimum pulse-width distortion.

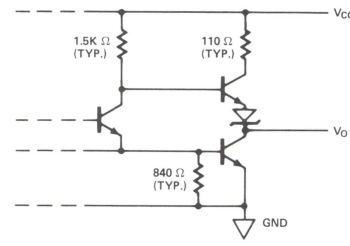
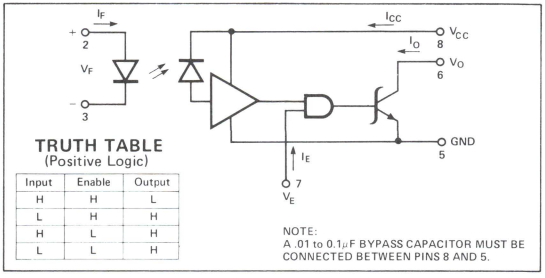


Figure 17. Typical HCPL-2400/11 Output Schematic

HEWLETT PACKARD

LSTTL/TTL COMPATIBLE OPTOCOUPLER

6N137



TRUTH TABLE
(Positive Logic)

Input	Enable	Output
H	H	L
L	H	H
H	L	H
L	L	H

NOTE:
A .01 to 0.1μF BYPASS CAPACITOR MUST BE CONNECTED BETWEEN PINS 8 AND 5.

Figure 1.

Features

- **LSTTL/TTL COMPATIBLE: 5 V SUPPLY**
- **HIGH SPEED: 10 MBd TYPICAL**
- **LOW INPUT CURRENT REQUIRED: 5 mA**
- **HIGH COMMON MODE REJECTION: >1000 V/μs TYPICAL**
- **GUARANTEED PERFORMANCE OVER TEMPERATURE**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**

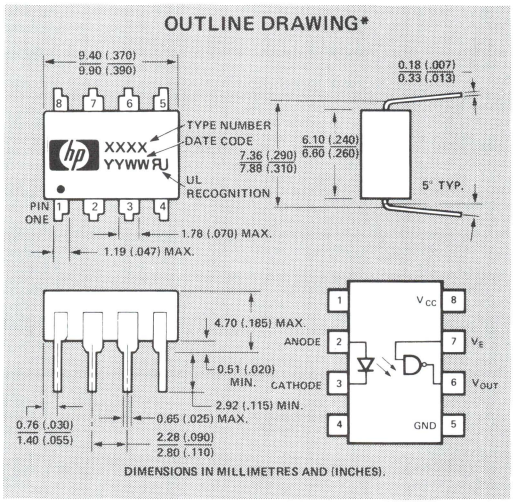
Description / Applications

The 6N137 consists of a GaAsP photon emitting diode and a unique integrated detector. The photons are collected in the detector by a photodiode and then amplified by a high gain linear amplifier that drives a Schottky clamped open collector output transistor. The circuit is temperature, current and voltage compensated.

This unique isolator design provides maximum DC and AC circuit isolation between input and output while achieving LSTTL/TTL circuit compatibility. The isolator operational parameters are guaranteed from 0°C to 70°C, such that a minimum input current of 5mA will sink an eight gate fan-out (13mA) at the output with 5 volt V_{CC} applied to the detector. This isolation and coupling is achieved with a typical propagation delay of 55ns. The enable input provides gating of the detector with input sinking and sourcing requirements compatible with LSTTL/TTL interfacing.

The 6N137 can be used in high speed digital interfacing applications where common mode signals must be rejected, such as for a line receiver and digital programming of floating power supplies, motors, and other machine control systems. It is also useful in digital/analog conversion applications, like compact disk players, for noise elimination. The open collector output provides capability for bussing, OR'ing and strobing.

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.



Recommended Operating Conditions

	Sym.	Min.	Max.	Units
Input Current, Low Level Each Channel	I_{FL}	0	250	μA
Input Current, High Level Each Channel	I_{FH}	6.3**	15	mA
High Level Enable Voltage	V_{EH}	2.0	V_{CC}	V
Low Level Enable Voltage (Output High)	V_{EL}	0	0.8	V
Supply Voltage, Output	V_{CC}	4.5	5.5	V
Fan Out (TTL Load)	N		8	
Operating Temperature	T_A	0	70	°C

Absolute Maximum Ratings*

(No derating required up to 70°C)

Storage Temperature ..... −55°C to +125°C
Operating Temperature ..... 0°C to +70°C
Lead Solder Temperature ..... 260°C for 10s
(1.6mm below seating plane)
Peak Forward Input Current ..... 40mA (t ≤ 1msec Duration)
Average Forward Input Current 20mA
Reverse Input Voltage 5V
Enable Input Voltage 5.5V
(Not to exceed V_{CC} by more than 500mV)
Supply Voltage - V_{CC} ..... 7V (1 Minute Maximum)
Output Current - I_O 50mA
Output Collector Power Dissipation 85mW
Output Voltage - V_O 7V

**6.3mA condition permits at least 20% CTR degradation guardband. Initial switching threshold is 5mA or less.

OPTOCOUPLERS

Electrical Characteristics

OVER RECOMMENDED TEMPERATURE (T_A = 0°C TO 70°C) UNLESS OTHERWISE NOTED

Parameter	Symbol	Min.	Typ.**	Max.	Units	Test Conditions	Figure	Note
High Level Output Current	I_{OH}*		2	250	μA	V_{CC}=5.5V, V_O=5.5V, I_F=250μA, V_E=2.0V	6	
Low Level Output Voltage	V_{OL}*		0.4	0.6	V	V_{CC}=5.5V, I_F=5mA, V_{EH}=2.0V I_{OL} (Sinking) =13mA	3,5	
High Level Enable Current	I_{EH}		-1.0		mA	V_{CC}=5.5V, V_E=2.0V		
Low Level Enable Current	I_{EL}*		-1.4	-2.0	mA	V_{CC}=5.5V, V_E=0.5V		
High Level Supply Current	I_{CCH}*		7	15	mA	V_{CC}=5.5V, I_F=0 V_E=0.5V		
Low Level Supply	I_{CCL}*		14	18	mA	V_{CC}=5.5V, I_F=10mA V_E=0.5V		
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O}= 3 kV dc, T_A= 25°C		5, 9
OPT 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50% t = 1 MIN		10
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	V_{I-O}=500V, T_A=25°C		5
Capacitance (Input-Output)	C_{I-O}		0.6		pF	f=1MHz, T_A=25°C		5
Input Forward Voltage	V_F*		1.5	1.75	V	I_F=10mA, T_A=25°C	4	8
Input Reverse Breakdown Voltage	BV_R*	5			V	I_R=10μA, T_A=25°C		
Input Capacitance	C_{IN}		60		pF	V_F=0, f=1MHz		
Current Transfer Ratio	CTR		700		%	I_F=5.0mA, R_L=100Ω	2	7

**All typical values are at V_{CC} = 5V, T_A = 25°C

Switching Characteristics at T_A=25°C, V_{CC}=5V

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Propagation Delay Time to High Output Level	t_{PLH}*		55	75	ns	R_L=350Ω, C_L=15pF, I_F=7.5mA	7,9	1
Propagation Delay Time to Low Output Level	t_{PHL}*		55	75	ns	R_L=350Ω, C_L=15pF, I_F=7.5mA	7,9	2
Pulse Width Distortion	$\lvert t_{PHL} - t_{PLH} \rvert$		10		ns	R_L=350Ω, C_L=15pF, I_F=7.5mA		
Output Rise-Fall Time (10-90%)	t_r, t_f		50, 20		ns	R_L=350Ω, C_L=15pF, I_F=7.5mA		
Propagation Delay Time of Enable from V_{EH} to V_{EL}	t_{ELH}		65		ns	R_L=350Ω, C_L=15pF, I_F=7.5mA, V_{EH}=3.0V, V_{EL}=0.5V	8	3
Propagation Delay Time of Enable from V_{EL} to V_{EH}	t_{EHL}		20		ns	R_L=350Ω, C_L=15pF, I_F=7.5mA V_{EH}=3.0V, V_{EL}=0.5V	8	4
Common Mode Transient Immunity at Logic High Output Level	$\lvert CM_H \rvert$		100		v/μs	V_{CM}=10V R_L=350Ω, V_O (min.)=2V, I_F=0mA	11	6
Common Mode Transient Immunity at Logic Low Output Level	$\lvert CM_L \rvert$		-300		v/μs	V_{CM}=10V R_L=350Ω, V_O (max.)=0.8V, I_F=5mA	11	6

*JEDEC Registered Data.

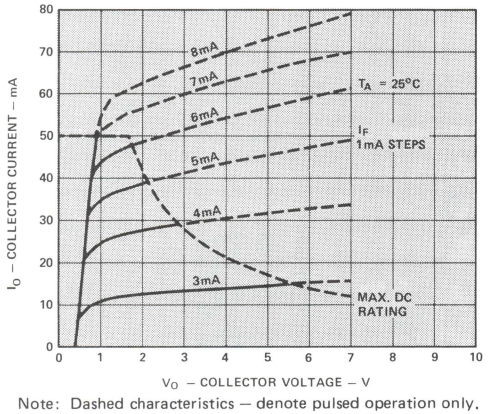
Operating Procedures and Definitions

Logic Convention. The 6N137 is defined in terms of positive logic.

Bypassing. A ceramic capacitor (.01 to 0.1μF) should be connected from pin 8 to pin 5 (Figure 12). Its purpose is to stabilize the operation of the high gain linear amplifier. Failure to provide the bypassing may impair the switching properties. The total lead length between capacitor and coupler should not exceed 20mm.

Polarities. All voltages are referenced to network ground (pin 5). Current flowing toward a terminal is considered positive.

Enable Input. No external pull-up required for a logic (1), i.e., can be open circuit.



Note: Dashed characteristics — denote pulsed operation only.

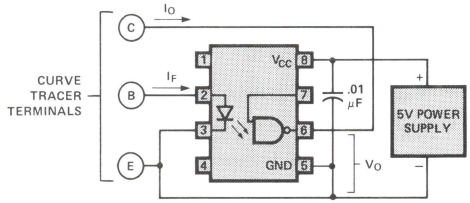
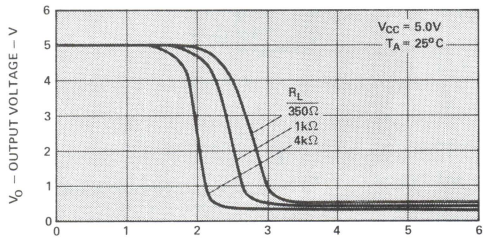


Figure 2. Optocoupler Collector Characteristics.



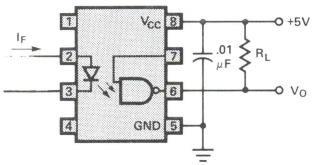


Figure 3. Input-Output Characteristics.

NOTES:

1. The t_{PLH} propagation delay is measured from the 3.75mA point on the trailing edge of the input pulse to the 1.5V point on the trailing edge of the output pulse.
2. The t_{PHL} propagation delay is measured from the 3.75mA point on the leading edge of the input pulse to 1.5V point on the leading edge of the output pulse.
3. The t_{ELH} enable propagation delay is measured from the 1.5V point of the trailing edge of the input pulse to the 1.5V point on the trailing edge of the output pulse.
4. The t_{EHL} enable propagation delay is measured from the 1.5V point on the leading edge of the input pulse to the 1.5V point on the leading edge of the output pulse.
5. Device considered a two terminal device: pins 2 and 3 shorted together, and pins 5, 6, 7, and 8 shorted together.
6. Common mode transient immunity in Logic High level is the maximum tolerable (positive) dV_{CM}/dt on the leading edge of the common mode pulse, V_{CM}, to assure that the output will remain in a Logic High state (i.e., V_O>2.0V). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) dV_{CM}/dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a Logic Low state (i.e., V_O<0.8V).
7. DC Current Transfer Ratio is defined as the ratio of the output collector current to the forward bias input current times 100%.
8. At 10mA V_F decreases with increasing temperature at the rate of 1.6mV/°C.
9. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
10. See Option 010 data sheet for more information.

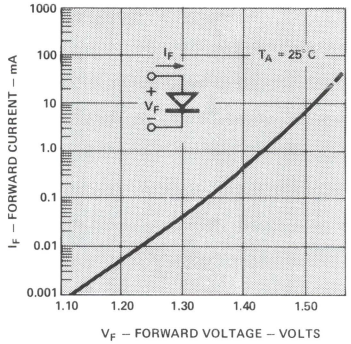


Figure 4. Input Diode Forward Characteristic.

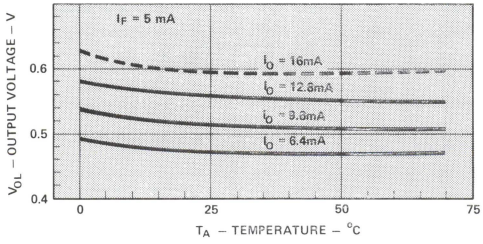


Figure 5. Output Voltage, V_{OL} vs. Temperature and Fan-Out.

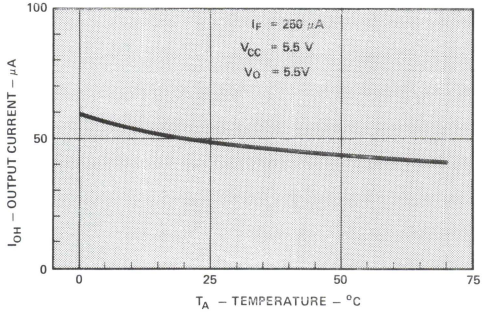


Figure 6. Output Current, I_{OH} vs. Temperature (I_F=250μA).

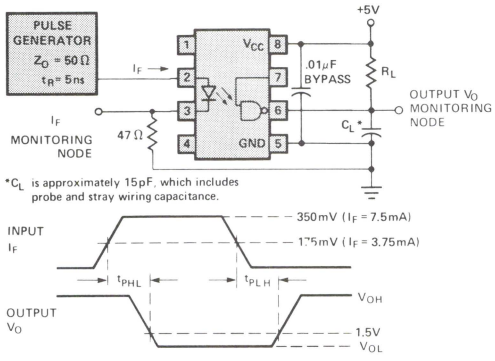


Figure 7. Test Circuit for t_{PHL} and t_{PLH}.**

**JEDEC Registered Data.

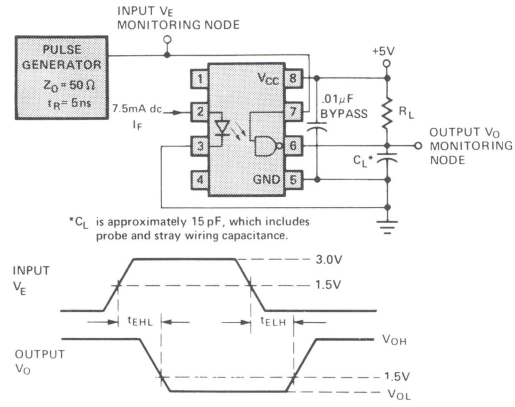


Figure 8. Test Circuit for t_{ELH} and t_{EHL}.

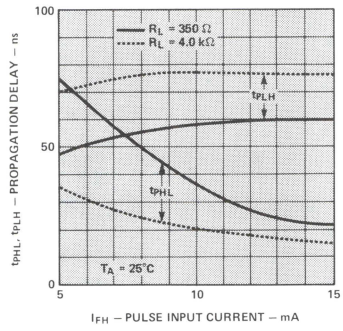


Figure 9. Propagation Delay, t_{PHL} and t_{PLH} vs. Pulse Input Current, I_{FH}.

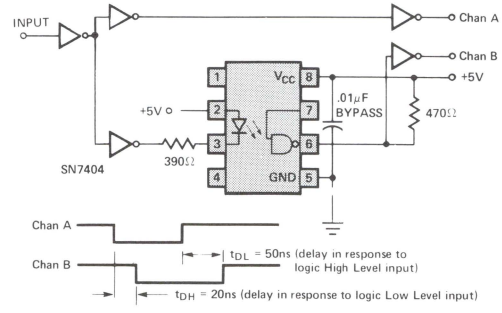
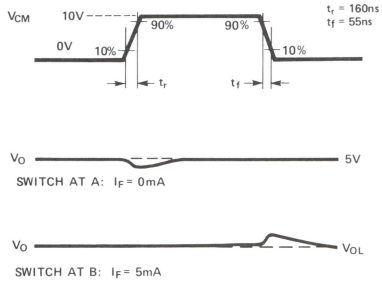


Figure 10. Response Delay Between TTL Gates.



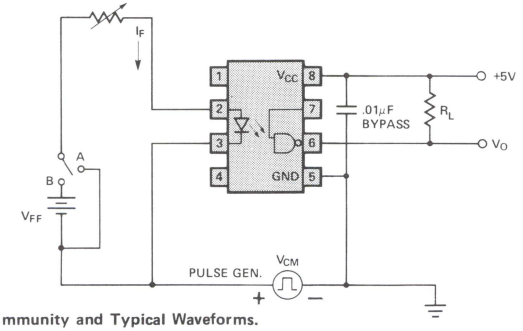


Figure 11. Test Circuit for Transient Immunity and Typical Waveforms.

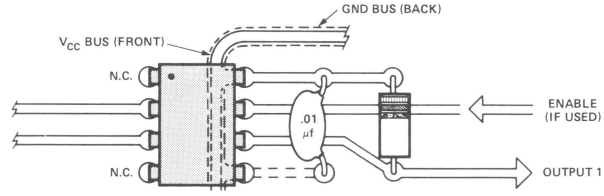
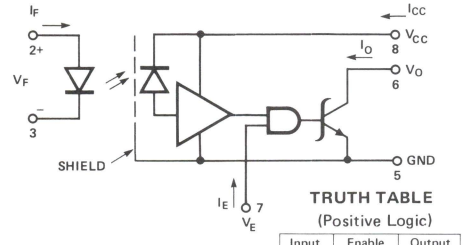


Figure 12. Recommended Printed Circuit Board Layout.

HEWLETT PACKARD

HIGH CMR, HIGH SPEED OPTOCOUPLER

HCPL-2601
HCPL-2611

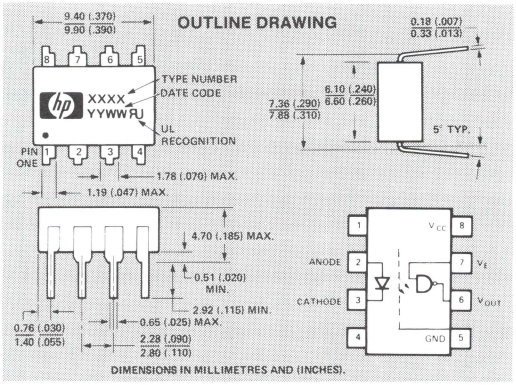


A 0.01 TO 0.1 μF BYPASS CAPACITOR MUST BE CONNECTED BETWEEN PINS 8 AND 5 (See Note 1).

TRUTH TABLE
(Positive Logic)

Input	Enable	Output
H	H	L
L	H	H
H	L	H
L	L	H

Figure 1. Schematic.



Features

- **INTERNAL SHIELD FOR HIGH COMMON MODE REJECTION (CMR)**
  HCPL-2601 = 1000 V/μs
  HCPL-2611 = 3500 V/μs
- **HIGH SPEED: 10 MBd TYPICAL**
- **LSTTL/TTL COMPATIBLE**
- **LOW INPUT CURRENT REQUIRED: 5 mA**
- **GUARANTEED PERFORMANCE OVER TEMPERATURE: 0°C to 70°C**
- **STROBABLE OUTPUT**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**

Description

The HCPL-2601/11 optically coupled gates combine a GaAsP light emitting diode and an integrated high gain photon detector. An enable input allows the detector to be strobed. The output of the detector I.C. is an open collector Schottky clamped transistor. The internal shield provides a guaranteed common mode transient immunity specification of 1000 V/μs for the 2601, and 3500 V/μs with the 2611.

This unique design provides maximum D.C. and A.C. circuit isolation while achieving TTL compatibility. The isolator D.C. operational parameters are guaranteed from 0° C to 70° C allowing troublefree system performance. This isolation is achieved with a typical propagation delay of 40 nsec.

The HCPL-2601/11 are suitable for high speed logic interfacing, input/output buffering, as line receivers in environments that conventional line receivers cannot tolerate and are recommended for use in extremely high ground or induced noise environments.

Applications

- Isolated Line Receiver
- Simplex/Multiplex Data Transmission
- Computer-Peripheral Interface
- Microprocessor System Interface
- Digital Isolation for A/D, D/A Conversion
- Switching Power Supply
- Instrument Input/Output Isolation
- Ground Loop Elimination
- Pulse Transformer Replacement

Recommended Operating Conditions

	Sym.	Min.	Max.	Units
Input Current, Low Level	I_{FL}	0	250	μA
Input Current, High Level	I_{FH}	6.3*	15	mA
Supply Voltage, Output	V_{CC}	4.5	5.5	V
High Level Enable Voltage	V_{EH}	2.0	V_{CC}	V
Low Level Enable Voltage	V_{EL}	0	0.8	V
Fan Out (TTL Load)	N		8	
Operating Temperature	T_A	0	70	°C

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

*6.3 mA condition permits at least 20% CTR degradation guard band. Initial switching threshold is 5mA or less.

OPTOCOUPLERS

Absolute Maximum Ratings

(No Derating Required up to 70°C)

Storage Temperature ..... −55°C to +125°C
Operating Temperature ..... 0°C to +70°C
Lead Solder Temperature ..... 260°C for 10 s
(1.6mm below seating plane)
Forward Input Current − I_F (see Note 2) ..... 20 mA
Reverse Input Voltage ..... 5 V
Supply Voltage − V_{CC} ..... 7V (1 Minute Maximum)
Enable Input Voltage − V_E ..... 5.5 V
(Not to exceed V_{CC} by more than 500 mV)
Output Collector Current − I_O ..... 25 mA
Output Collector Power Dissipation ..... 40 mW
Output Collector Voltage − V_O ..... 7 V

Electrical Characteristics

(Over Recommended Temperature, T_A = 0°C to +70°C, Unless Otherwise Noted)

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions	Figure	Note
High Level Output Current	I_{OH}		20	250	μA	V_{CC} = 5.5V, V_O = 5.5V, I_F = 250 μA, V_E = 2.0 V	2	
Low Level Output Voltage	V_{OL}		0.4	0.6	V	V_{CC} = 5.5V, I_F = 5 mA V_E = 2.0 V, I_{OL} (Sinking) = 13 mA	3,5	
High Level Supply Current	I_{CCH}		10	15	mA	V_{CC} = 5.5V, I_F = 0, V_E = 0.5 V		
Low Level Supply Current	I_{CCL}		15	19	mA	V_{CC} = 5.5V, I_F = 10 mA, V_E = 0.5 V		
Low Level Enable Current	I_{EL}		−1.4	−2.0	mA	V_{CC} = 5.5 V, V_E = 0.5 V		
High Level Enable Current	I_{EH}		−1.0		mA	V_{CC} = 5.5 V, V_E = 2.0V		
High Level Enable Voltage	V_{EH}	2.0			V			11
Low Level Enable Voltage	V_{EL}			0.8	V			
Input Forward Voltage	V_F		1.5	1.75	V	I_F = 10 mA, T_A = 25°C	4	
Input Reverse Breakdown Voltage	BV_R	5			V	I_R = 10 μA, T_A = 25°C		
Input Capacitance	C_{IN}		60		pF	V_F = 0, f = 1 MHz		
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		−1.6		mV/°C	I_F = 10 mA		
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 3 kV dc, T_A = 25°C		3, 12
OPT 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50% t = 1 MIN		13
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	V_{I-O} = 500 V		3
Capacitance (Input-Output)	C_{I-O}		0.6		pF	f = 1 MHz		3

*All typical values are at V_{CC} = 5V, T_A = 25°C.

Switching Characteristics (T_A = 25°C, V_{CC} = 5V)

Parameter	Symbol		Min.	Typ.	Max.	Units	Test Conditions		Figure	Note
Propagation Delay Time to High Output Level	t_{PLH}			40	75	ns	R_L = 350 Ω, C_L = 15 pF, I_F = 7.5 mA		6	4
Propagation Delay Time to Low Output Level	t_{PHL}			40	75	ns			6	5
Pulse Width Distortion	$\lvert t_{PHL}-t_{PLH}\rvert$			10		ns				
Output Rise Time (10-90%)	t_r			20		ns				
Output Fall Time (90-10%)	t_f			30		ns				
Propagation Delay Time of Enable from V_{EH} to V_{EL}	t_{ELH}			25		ns	R_L = 350 Ω, C_L = 15 pF, I_F = 7.5 mA, V_{EH} = 3 V, V_{EL} = 0 V		9	6
Propagation Delay Time of Enable from V_{EL} to V_{EH}	t_{EHL}			25		ns	R_L = 350 Ω, C_L = 15 pF, I_F = 7.5 mA, V_{EH} = 3 V, V_{EL} = 0 V		9	7
Common Mode Transient Immunity at High Output Level	$\lvert CM_H\rvert$	2601	1000	10,000		V/μs	V_{CM} = 50 V	$V_{O(MIN)}$ = 2 V, R_L = 350 Ω, I_F = 0 mA	12	8, 10
		2611	3500			V/μs	V_{CM} = 400 V			
Common Mode Transient Immunity at Low Output Level	$\lvert CM_L\rvert$	2601	1000	10,000		V/μs	V_{CM} = 50 V	$V_{O(MAX)}$ = 0.8 V, R_L = 350 Ω, I_F = 7.5 mA	12	9, 10
		2611	3500			V/μs	V_{CM} = 400 V			

NOTES:

1. Bypassing of the power supply line is required, with a 0.01 μF ceramic disc capacitor adjacent to each isolator as illustrated in Figure 15. The power supply bus for the isolator(s) should be separate from the bus for any active loads, otherwise a larger value of bypass capacitor (up to 0.1 μF) may be needed to suppress regenerative feedback via the power supply.
2. Peaking circuits may produce transient input currents up to 50 mA, 50 ns maximum pulse width, provided average current does not exceed 20 mA.
3. Device considered a two terminal device: pins 1, 2, 3 and 4 shorted together, and pins 5, 6, 7 and 8 shorted together.
4. The t_{PLH} propagation delay is measured from the 3.75 mA point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
5. The t_{PHL} propagation delay is measured from the 3.75 mA point on the leading edge of the input pulse to the 1.5V point on the leading edge of the output pulse.
6. The t_{ELH} enable propagation delay is measured from the 1.5 V point on the trailing edge of the enable input pulse to the 1.5 V point on the trailing edge of the output pulse.
7. The t_{EHL} enable propagation delay is measured from the 1.5 V point on the leading edge of the enable input pulse to the 1.5 V point on the leading edge of the output pulse.
8. CM_H is the maximum tolerable rate of rise of the common mode voltage to assure that the output will remain in a high logic state (i.e., $V_{OUT} > 2.0$ V).
9. CM_L is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state (i.e., $V_{OUT} < 0.8$ V).
10. For sinusoidal voltages, $\left(\frac{|dv_{CM}|}{dt}\right)_{max} = \pi f_{CM} V_{CM}$ (p-p)
11. No external pull up is required for a high logic state on the enable input.
12. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
13. See Option 010 data sheet for more information.

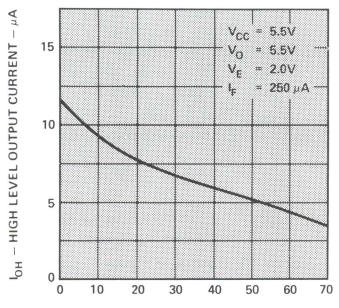


Figure 2. High Level Output Current vs. Temperature.

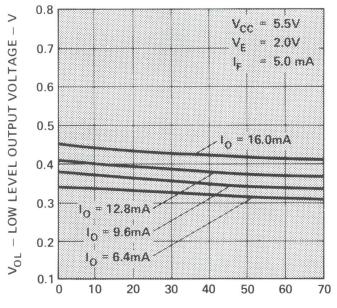


Figure 3. Low Level Output Voltage vs. Temperature.

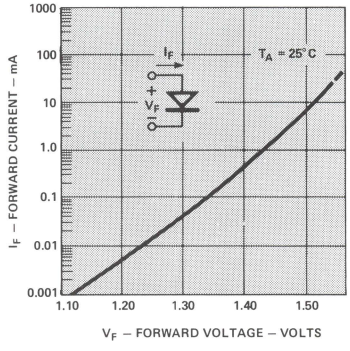


Figure 4. Input Diode Forward Characteristic.

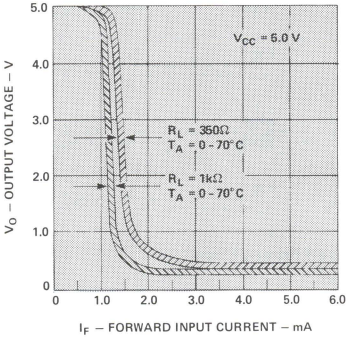


Figure 5. Output Voltage vs. Forward Input Current.

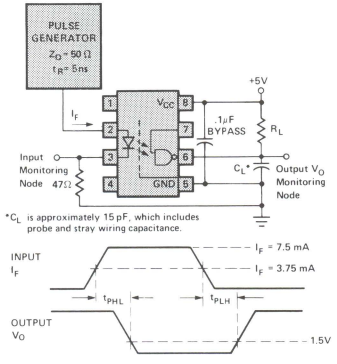


Figure 6. Test Circuit for t_{PHL} and t_{PLH}.

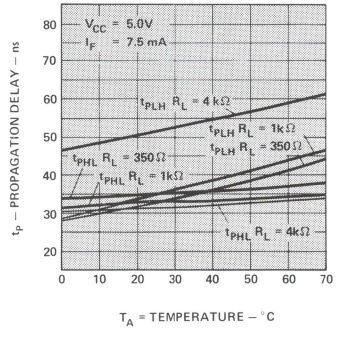


Figure 7. Propagation Delay vs. Temperature.

OPTOCOUPLERS

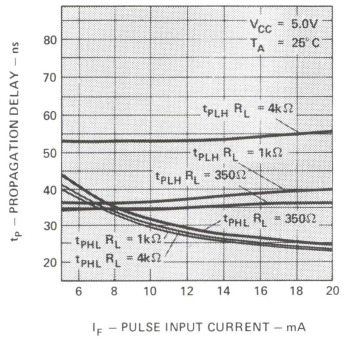


Figure 8. Propagation Delay vs. Pulse Input Current.

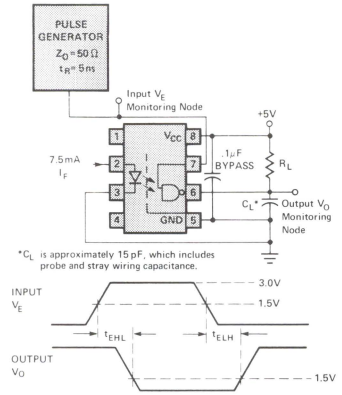


Figure 9. Test Circuit for t_{EHL} and t_{ELH}.

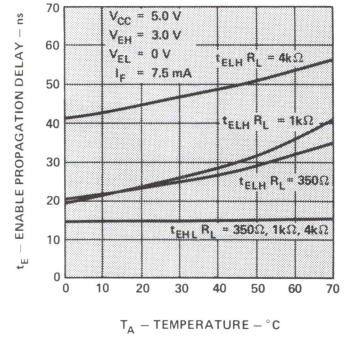


Figure 10. Enable Propagation Delay vs. Temperature.

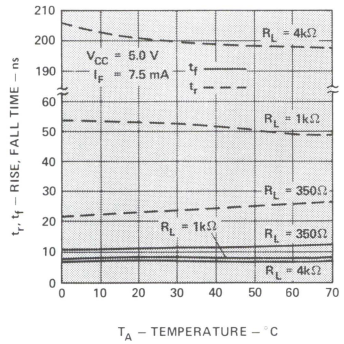


Figure 11. Rise, Fall Time vs. Temperature.

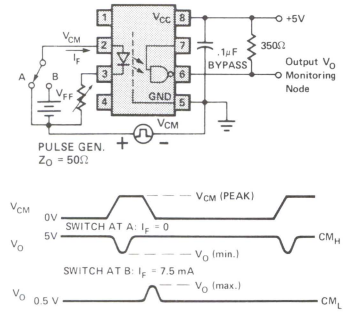


Figure 12. Test Circuit for Common Mode Transient Immunity and Typical Waveforms.

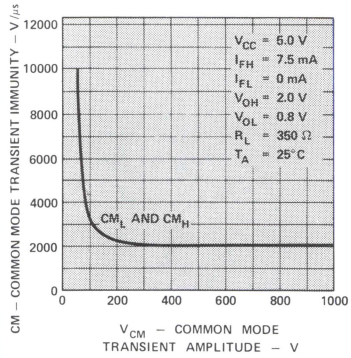


Figure 13. Common Mode Transient Immunity vs. Common Mode Transient Amplitude.

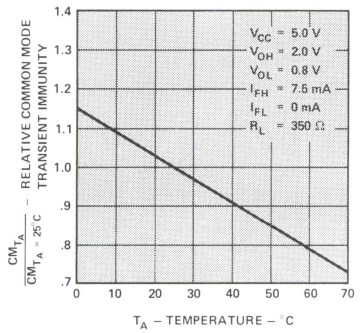


Figure 14. Relative Common Mode Transient Immunity vs. Temperature.

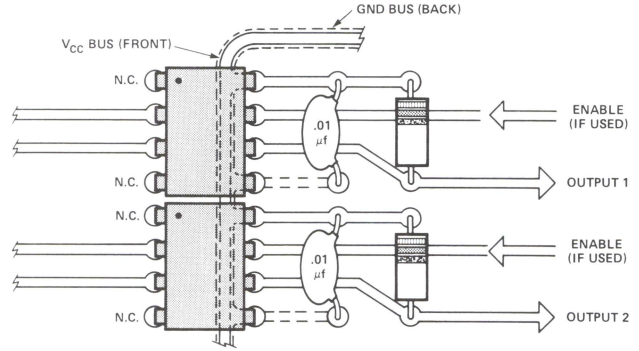
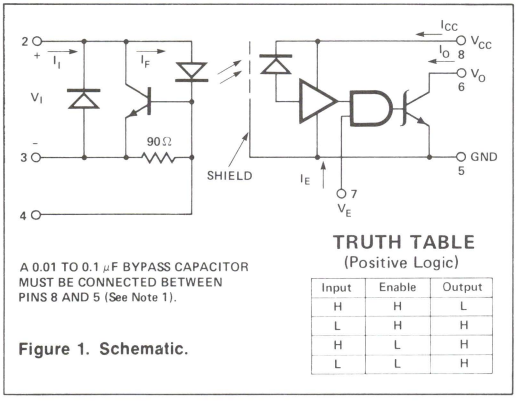


Figure 15. Recommended Printed Circuit Board Layout.

HEWLETT PACKARD

HIGH CMR LINE RECEIVER OPTOCOUPLER

HCPL-2602
HCPL-2612

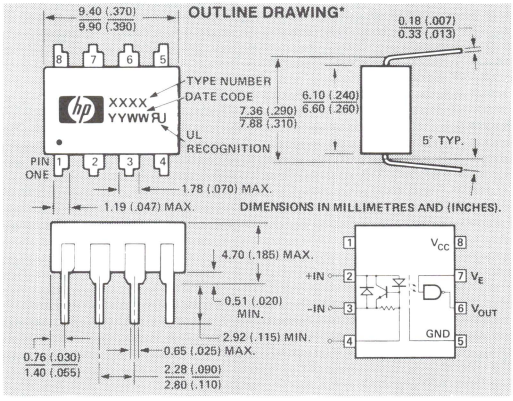


A 0.01 TO 0.1 μF BYPASS CAPACITOR MUST BE CONNECTED BETWEEN PINS 8 AND 5 (See Note 1).

Figure 1. Schematic.

TRUTH TABLE
(Positive Logic)

Input	Enable	Output
H	H	L
L	H	H
H	L	H
L	L	H



Features

- **HIGH COMMON MODE REJECTION**
  2602 = 1000 V/μs
  2612 = 3500 V/μs
- **LINE TERMINATION INCLUDED — NO EXTRA CIRCUITRY REQUIRED**
- **ACCEPTS A BROAD RANGE OF DRIVE CONDITIONS**
- **GUARDBANDED FOR LED DEGRADATION**
- **LED PROTECTION MINIMIZES LED EFFICIENCY DEGRADATION**
- **HIGH SPEED — 10MBd (LIMITED BY TRANSMISSION LINE IN MANY APPLICATIONS)**
- **INTERNAL SHIELD PROVIDES EXCELLENT COMMON MODE REJECTION**
- **EXTERNAL BASE LEAD ALLOWS "LED PEAKING" AND LED CURRENT ADJUSTMENT**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**
- **HCPL-1930/1 COMPATIBILITY**

Description

The HCPL-2602/12 optically coupled line receivers combine a GaAsP light emitting diode, an input current regulator and an integrated high gain photon detector. The input regulator serves as a line termination for line receiver applications. It clamps the line voltage and regulates the LED current so line reflections do not interfere with circuit performance.

The regulator allows a typical LED current of 8.5 mA before it starts to shunt excess current. The output of the detector IC is an open collector Schottky clamped transistor. An enable input gates the detector. The internal detector shield provides a guaranteed common mode transient immunity specification of 1000 V/μs for the 2602, and 3500 V/μs for the 2612.

Applications

- **Isolated Line Receiver**
- **Simplex/Multiplex Data Transmission**
- **Computer-Peripheral Interface**
- **Microprocessor System Interface**
- **Digital Isolation for A/D, D/A Conversion**
- **Current Sensing**
- **Instrument Input/Output Isolation**
- **Ground Loop Elimination**
- **Pulse Transformer Replacement**

DC specifications are defined similar to TTL logic and are guaranteed from 0°C to 70°C allowing trouble free interfacing with digital logic circuits. An input current of 5 mA will sink an eight gate fan-out (TTL) at the output with a typical propagation delay from input to output of only 45 nsec.

The HCPL-2602/12 are useful as line receivers in high noise environments that conventional line receivers cannot tolerate. The higher LED threshold voltage provides improved immunity to differential noise and the internally shielded detector provides orders of magnitude improvement in common mode rejection with little or no sacrifice in speed.

CAUTION: The small junction sizes inherent to the design of this bipolar component increase the component's susceptibility to damange from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

OPTOCOUPLERS

Recommended Operating Conditions

	Sym.	Min.	Max.	Units
Input Current, Low Level	I_{IL}	0	250	μA
Input Current, High Level	I_{IH}	6.3*	60	mA
Supply Voltage, Output	V_{CC}	4.5	5.5	V
High Level Enable Voltage	V_{EH}	2.0	Vcc	V
Low Level Enable Voltage	V_{EL}	0	0.8	V
Fan Out (TTL Load)	N		8	
Operating Temperature	T_A	0	70	°C

*6.3 mA condition permits at least 20% degradation guardband. Initial switching threshold is 5 mA or less.

Absolute Maximum Ratings

Storage Temperature ..... −55°C to +125°C
Operating Temperature ..... 0°C to +70°C
Lead Solder Temperature ..... 260°C for 10 s (1.6mm below seating plane)
Forward Input Current — I_I ..... 60 mA
Reverse Input Current ..... 60 mA
Supply Voltage — V_{CC} ..... 7V (1 Minute Maximum)
Enable Input Voltage — V_E ..... 5.5 V (Not to exceed V_{CC} by more than 500 mV)
Output Collector Current — I_O ..... 25 mA
Output Collector Power Dissipation ..... 40 mW
Output Collector Voltage — V_O ..... 7 V
Input Current, Pin 4 ..... ±10 mA

NOTES:

1. Bypassing of the power supply line is required, with a 0.01 μF ceramic disc capacitor adjacent to each isolator as illustrated in Figure 15. The power supply bus for the isolator(s) should be separate from the bus for any active loads, otherwise a larger value of bypass capacitor (up to 0.1 μF) may be needed to suppress regenerative feedback via the power supply.
2. Device considered a two terminal device: pins 1, 2, 3 and 4 shorted together, and pins 5, 6, 7 and 8 shorted together.
3. The t_{PLH} propagation delay is measured from the 3.75 mA point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
4. The t_{PHL} propagation delay is measured from the 3.75 mA point on the leading edge of the input pulse to the 1.5V point on the leading edge of the output pulse.
5. The t_{ELH} enable propagation delay is measured from the 1.5 V point on the trailing edge of the enable input pulse to the 1.5 V point on the trailing edge of the output pulse.
6. The t_{EHL} enable propagation delay is measured from the 1.5 V point on the leading edge of the enable input pulse to the 1.5 V point on the leading edge of the output pulse.
7. CM_H is the maximum tolerable rate of rise of the common mode voltage to assure that the output will remain in a high logic state (i.e., V_{OUT} >2.0 V).
8. CM_L is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state (i.e., V_{OUT} <0.8 V).
9. For sinusoidal voltages, $\left(\frac{|dv_{CM}|}{dt}\right)_{max} = \pi f_{CM} V_{CM}$ (p-p)
10. No external pull up is required for a high logic state on the enable input.
11. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
12. See Option 010 data sheet for more information.

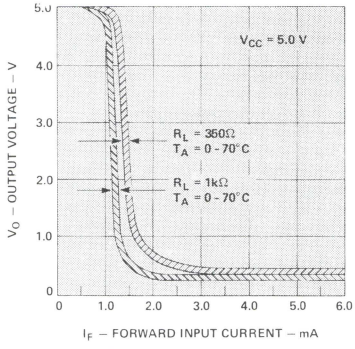


Figure 2. Output Voltage vs. Forward Input Current.

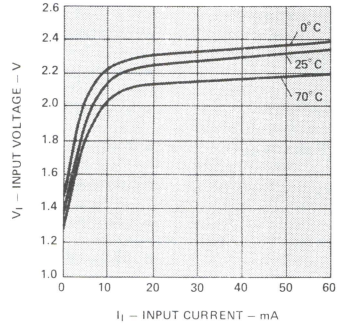


Figure 3. Input Characteristics.

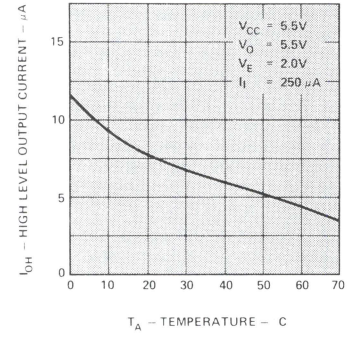


Figure 4. High Level Output Current vs. Temperature.

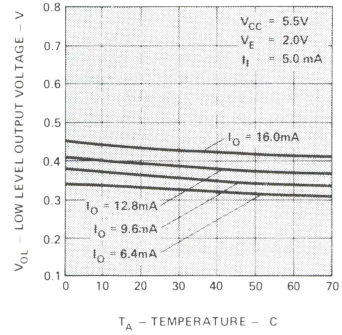


Figure 5. Low Level Output Voltage vs. Temperature.

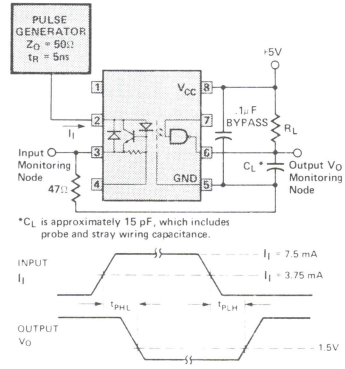


Figure 6. Test Circuit for t_{PHL} and t_{PLH}.

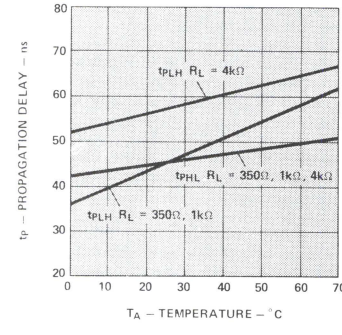


Figure 7. Propagation Delay vs. Temperature.

Electrical Characteristics

(Over Recommended Temperature, T_A = 0° C to +70° C, Unless Otherwise Noted)

Parameter	Symbol	Min.	Typ.**	Max.	Units	Test Conditions	Figure	Note
High Level Output Current	I_{OH}		20	250	μA	V_{CC} = 5.5V, V_O = 5.5V I_I=250 μA, V_E=2.0V	4	
Low Level Output Voltage	V_{OL}		0.4	0.6	V	V_{CC}=5.5V, I_I=5 mA V_E=2.0V, I_{OL} (Sinking)=13 mA	2,5	
Input Voltage	V_I		2.0	2.4	V	I_I=5 mA	3	
			2.3	2.7		I_I=60 mA	3	
Input Reverse Voltage	V_R		0.75	0.95	V	I_R=5 mA		
Low Level Enable Current	I_{EL}		-1.4	-2.0	mA	V_{CC}=5.5V, V_E=0.5V		
High Level Enable Current	I_{EH}		-1.0		mA	V_{CC}=5.5V, V_E=2.0V		
High Level Enable Voltage	V_{EH}	2.0			V			10
Low Level Enable Voltage	V_{EL}			0.8	V			
High Level Supply Current	I_{CCH}		10	15	mA	V_{CC}=5.5V, I_I=0, V_E=0.5V		
Low Level Supply Current	I_{CCL}		16	19	mA	V_{CC}=5.5V, I_I=60 mA V_E=0.5V		
Input Capacitance	C_{IN}		90		pF	V_I=0, f=1 MHz, (PIN 2-3)		
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O}= 3 kV dc, T_A= 25° C		2, 11
OPT 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50% t = 1 MIN		12
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	V_{I-O}=500V		2
Capacitance (Input-Output)	C_{I-O}		0.6		pF	f = 1 MHz		2

**All typical values are at V_{CC} = 5V, T_A = 25° C.

Switching Characteristics

(T_A = 25° C, V_{CC} = 5V)

Parameter	Symbol		Min.	Typ.	Max.	Units	Test Conditions		Figure	Note
Propagation Delay Time to High Output Level	t_{PLH}			45	75	ns	R_L = 350 Ω C_L = 15 pF I_I = 7.5 mA		6	3
Propagation Delay Time to Low Output Level	t_{PHL}			45	75	ns			6	4
Output Rise Time (10-90%)	t_r			25		ns				
Output Fall Time (90-10%)	t_f			25		ns				
Propagation Delay Time of Enable from V_{EH} to V_{EL}	t_{ELH}			15		ns	R_L = 350 Ω, C_L = 15 pF, I_I = 7.5 mA, V_{EH} = 3 V, V_{EL} = 0 V		10	5
Propagation Delay Time of Enable from V_{EL} to V_{EH}	t_{EHL}			15					10	6
Common Mode Transient Immunity at High Output Level	$\|CM_H\|$	2602	1000	10,000		V/μs	V_{CM} = 50 V	$V_{O(MIN)}$ = 2 V R_L = 350 Ω I_I = 0 mA	12	7, 9
		2612	3500			V/μs	V_{CM} = 300 V			
Common Mode Transient Immunity at Low Output Level	$\|CM_L\|$	2602	1000	10,000		V/μs	V_{CM} = 50 V	$V_{O(MAX)}$ = 0.8 V R_L = 350 Ω I_I = 7.5 mA	12	8, 9
		2612	3500			V/μs	V_{CM} = 300 V			

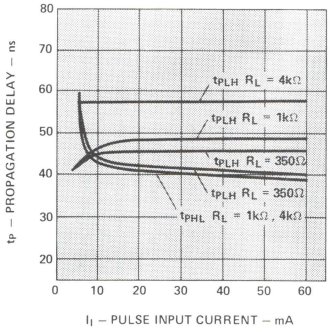


Figure 8. Propagation Delay vs. Pulse Input Current.

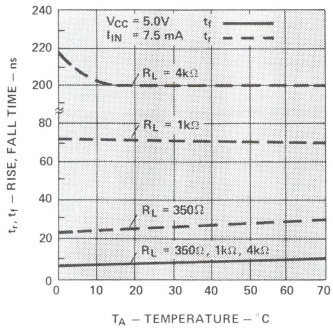


Figure 9. Rise, Fall Time vs. Temperature.

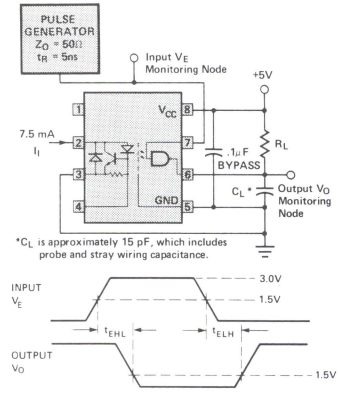


Figure 10. Test Circuit for t_{EHL} and t_{ELH}.

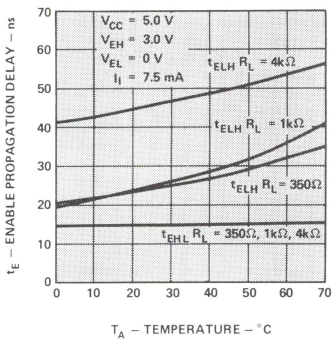


Figure 11. Enable Propagation Delay vs. Temperature.

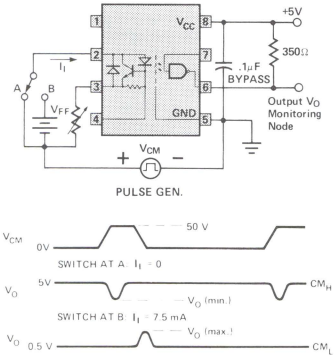


Figure 12. Test Circuit for Common Mode Transient Immunity and Typical Waveforms.

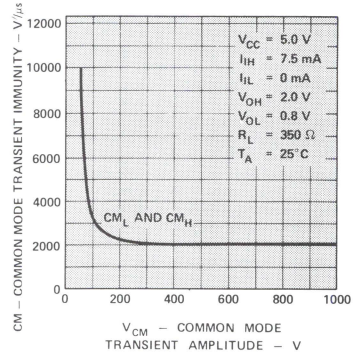


Figure 13. Common Mode Transient Immunity vs. Common Mode Transient Amplitude.

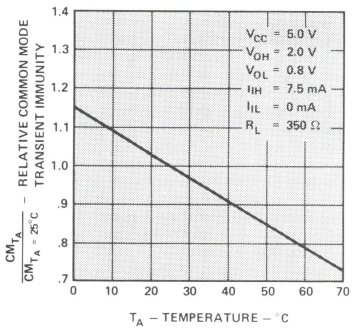


Figure 14. Relative Common Mode Transient Immunity vs. Temperature.

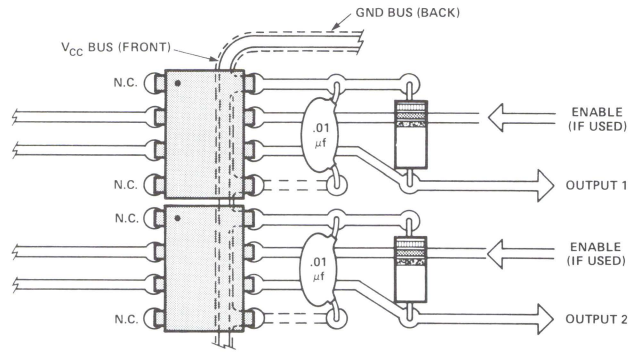


Figure 15. Recommended Printed Circuit Board Layout.

Using the HCPL-2602/12 Line Receiver Optocouplers

The primary objectives to fulfill when connecting an optocoupler to a transmission line are to provide a minimum, but not excessive, LED current and to properly terminate the line. The internal regulator in the HCPL-2602/12 simplifies this task. Excess current from variable drive conditons such as line length variations, line driver differences and power supply fluctuations are shunted by the regulator. In fact, with the LED current regulated, the line current can be increased to improve the immunity of the system to differential-mode-noise and to enhance the data rate capability. The designer must keep in mind the 60 mA input current maximum rating of the HCPL-2602/12 in such cases, and may need to use series limiting or shunting to prevent overstress.

Design of the termination circuit is also simplified; in most cases the transmission line can simply be connected directly to the input terminals of the HCPL-2602/12 without the need for additional series or shunt resistors. If reversing line drive is used it may be desirable to use two HCPL-2602/12 or an external Schottky diode to optimize data rate.

Polarity Non-Reversing Drive

High data rates can be obtained with the HCPL-2602/12 with polarity non-reversing drive. Figure (a) illustrates how a 74S140 line driver can be used with the HCPL-2602/12 and shielded, twisted pair or coax cable without any additional components. There are some reflections due to the "active termination" but they do not interfere with circuit performance because the regulator clamps the line voltage. At longer line lengths t_{PLH} increases faster than t_{PHL} since the switching threshold is not exactly halfway between asymptotic line conditions. If optimum data rate is desired, a series resistor and peaking capacitor can be used to equalize t_{PLH} and t_{PHL}. In general, the peaking capacitance should be as large as possible; however, if it is too large it may keep the regulator from achieving turn-off during the negative (or zero) excursions of the input signal. A safe rule:

make $C \leq 16t$
where C = peaking capacitance in picofarads
t = data bit interval in nanoseconds

Polarity Reversing Drive

A single HCPL-2602/12 can also be used with polarity reversing drive (Figure b). Current reversal is obtained by way of the substrate isolation diode (substrate to collector). Some reduction of data rate occurs, however, because the substrate diode stores charge, which must be removed when the current changes to the forward direction. The effect of this is a longer t_{PHL}. This effect can be eliminated and data rate improved considerably by use of a Schottky diode on the input of the HCPL-2602/12.

For optimum noise rejection as well as balanced delays a split-phase termination should be used along with a flip-flop at the output (Figure c). The result of current reversal in split-phase operation is seen in Figure (c) with switches A and B both OPEN. The coupler inputs are then connected in ANTI-SERIES; however, because of the higher steady-state termination voltage, in comparison to the single HCPL-2602/12 termination, the forward current in the substrate diode is lower. and consequently there is less junction charge to deal with when switching.

Closing switch B with A open is done mainly to enhance common mode rejection, but also reduces propagation delay slightly because line-to-line capacitance offers a slight peaking effect. With switches A and B both CLOSED, the shield acts as a current return path which prevents either input substrate diode from becoming reversed biased. Thus the data rate is optimized as shown in Figure (c).

Improved Noise Rejection

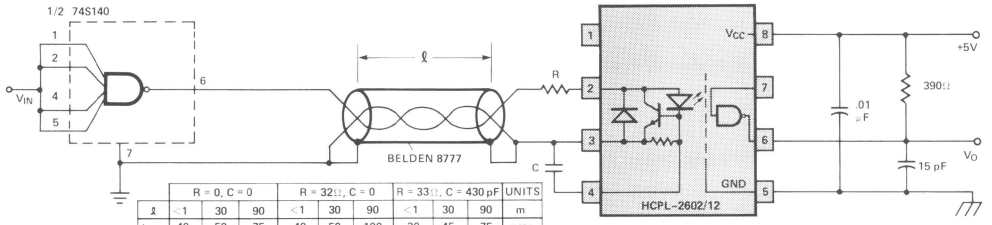
Use of additional logic at the output of two HCPL-2602/12's operated in the split phase termination, will greatly improve system noise rejection in addition to balancing propagation delays as discussed earlier.

A NAND flip-flop offers infinite common mode rejection (CMR) for NEGATIVELY sloped common mode transients but requires $t_{PHL} > t_{PLH}$ for proper operation. A NOR flip-flop has infinite CMR for POSITIVELY sloped transients but requires $t_{PHL} < t_{PLH}$ for proper operation. An exclusive-OR flip-flop has infinite CMR for common mode transients of EITHER polarity and operates with either $t_{PHL} > t_{PLH}$ or $t_{PHL} < t_{PLH}$.

With the line driver and transmission line shown in Figure (c), $t_{PHL} > t_{PLH}$, so NAND gates are preferred in the R-S flip-flop. A higher drive amplitude or different circuit configuration could make $t_{PHL} < t_{PLH}$, in which case NOR gates would be preferred. If it is not known whether $t_{PHL} > t_{PLH}$ or $t_{PHL} < t_{PLH}$, or if the drive conditions may vary over the boundary for these conditions, the exclusive-OR flip-flop of Figure (d) should be used.

RS-422 and RS-423

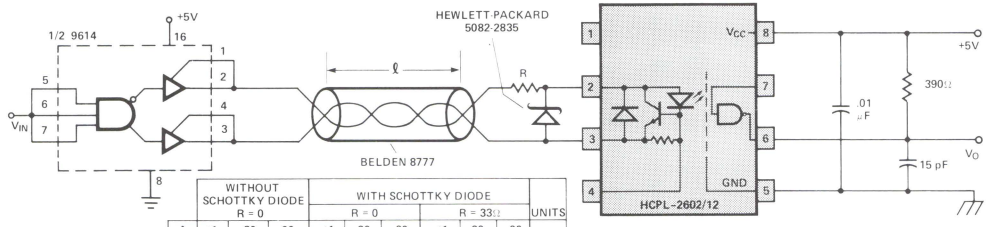
Line drivers designed for RS-422 and RS-423 generally provide adequate voltage and current for operating the HCPL-2602/12. Most drivers also have characteristics allowing the HCPL-2602/12 to be connected directly to the driver terminals. Worst case drive conditions, however, would require current shunting to prevent overstress of the HCPL-2602/12.



	R = 0, C = 0			R = 32Ω, C = 0			R = 33Ω, C = 430 pF			UNITS
ℓ	<1	30	90	<1	30	90	<1	30	90	m
t_{PHL}	40	50	75	40	50	100	30	45	75	nsec
t_{PLH}	45	65	175	40	50	80	40	45	75	nsec

PROPAGATION TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS.

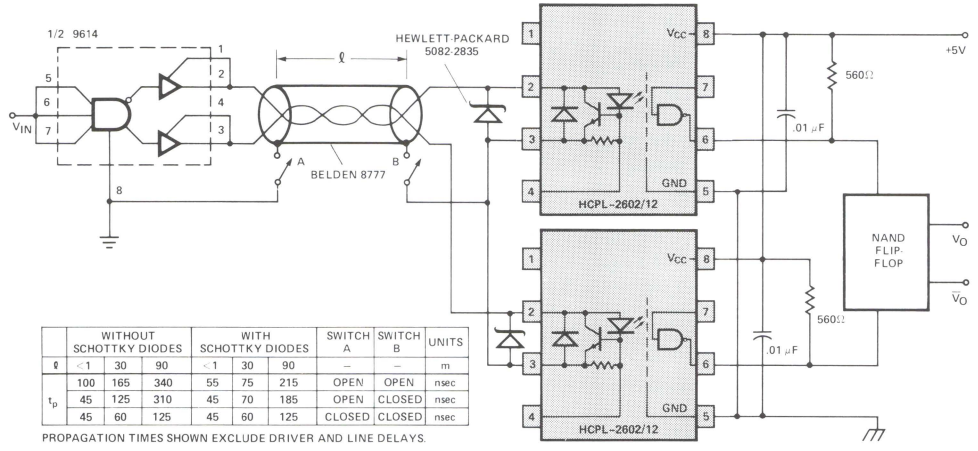
Figure a. Polarity Non-Reversing.



	WITHOUT SCHOTTKY DIODE R = 0			WITH SCHOTTKY DIODE R = 0			WITH SCHOTTKY DIODE R = 33Ω			UNITS
ℓ	<1	30	90	<1	30	90	<1	30	90	m
t_{PHL}	210	365	450	50	80	235	50	70	200	nsec
t_{PLH}	35	45	60	35	45	60	35	45	60	nsec

PROPAGATION TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS.

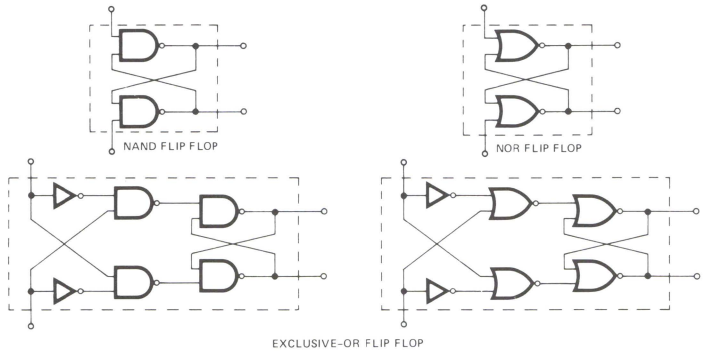
Figure b. Polarity Reversing, Single Ended.



	WITHOUT SCHOTTKY DIODES			WITH SCHOTTKY DIODES			SWITCH A	SWITCH B	UNITS
ℓ	<1	30	90	<1	30	90	–	–	m
t_p	100	165	340	55	75	215	OPEN	OPEN	nsec
	45	125	310	45	70	185	OPEN	CLOSED	nsec
	45	60	125	45	60	125	CLOSED	CLOSED	nsec

PROPAGATION TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS.

Figure c. Polarity Reversing, Split Phase.



NAND flip flop tolerates simultaneously HIGH inputs; NOR flip flop tolerates simultaneously LOW inputs; EXCLUSIVE-OR flip flop tolerates simultaneously HIGH OR LOW inputs without causing either of the outputs to change.

Figure d. Flip Flop Configurations.

HEWLETT PACKARD

DUAL TTL COMPATIBLE OPTOCOUPLER

HCPL-2630

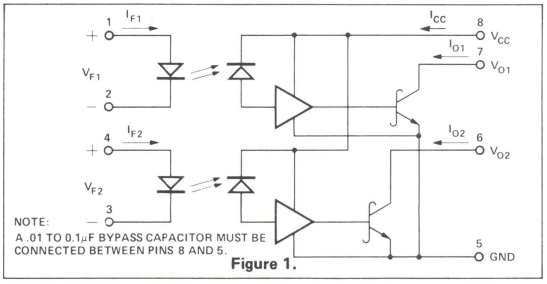


Figure 1.

Features

- **LSTTL/TTL COMPATIBLE: 5V SUPPLY**
- **HIGH SPEED: 10 MBd TYPICAL**
- **LOW INPUT CURRENT REQUIRED: 5 mA**
- **GUARANTEED PERFORMANCE OVER TEMPERATURE**
- **HIGH DENSITY PACKAGING**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**

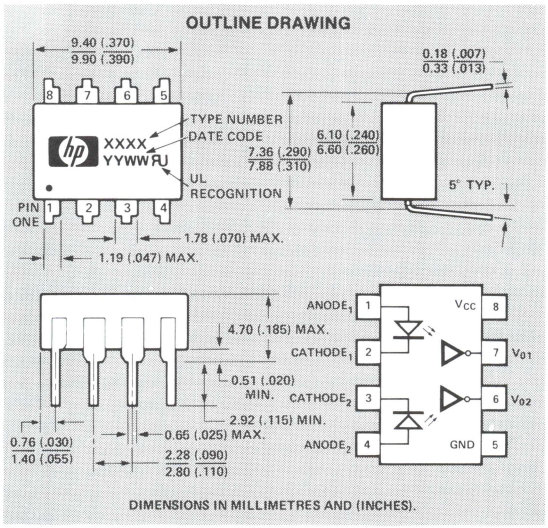
Description/Applications

The HCPL-2630 consists of a pair of inverting optically coupled gates each with a GaAsP photon emitting diode and a unique integrated detector. The photons are collected in the detector by a photodiode and then amplified by a high gain linear amplifier that drives a Schottky clamped open collector output transistor. Each circuit is temperature, current and voltage compensated.

This unique dual coupler design provides maximum DC and AC circuit isolation between each input and output while achieving LSTTL/TTL circuit compatibility. The coupler operational parameters are guaranteed from 0°C to 70°C, such that a minimum input current of 5 mA in each channel will sink an eight gate fan-out (13 mA) at the output with 5 volt V_{CC} applied to the detector. This isolation and coupling is achieved with a typical propagation delay of 55 nsec.

The HCPL-2630 can be used in high speed digital interface applications where common mode signals must be rejected such as for a line receiver and digital programming of floating power supplies, motors, and other machine control systems. It is also usefull in digital/analog conversion applications, like compact disk players, for noise elimination.

The open collector output provides capability for bussing, strobing and "WIRED-OR" connection. In all applications, the dual channel configuration allows for high density packaging, increased convenience and more usable board space.



Recommended Operating Conditions

	Sym.	Min.	Max.	Units
Input Current, Low Level Each Channel	I_{FL}	0	250	μA
Input Current, High Level Each Channel	I_{FH}	6.3*	15	mA
Supply Voltage, Output	V_{CC}	4.5	5.5	V
Fan Out (TTL Load) Each Channel	N		8	
Operating Temperature	T_A	0	70	°C

Absolute Maximum Ratings

(No derating required up to 70°C)

Storage Temperature ..... -55°C to +125°C
Operating Temperature ..... 0°C to +70°C
Lead Solder Temperature ..... 260°C for 10s (1.6mm below seating plane)
Peak Forward Input Current (each channel) ..... 30 mA (≤ 1 msec Duration)
Average Forward Input Current (each channel) ..... 15 mA
Reverse Input Voltage (each channel) 5V
Supply Voltage - V_{CC} ..... 7V (1 Minute Maximum)
Output Current - I_O (each channel) ..... 16 mA
Output Voltage - V_O (each channel) 7V
Output Collector Power Dissipation ..... 60 mW

*6.3mA condition permits at least 20% CTR degradation guardband. Initial switching threshold is 5mA or less.

OPTOCOUPLERS

Electrical Characteristics

OVER RECOMMENDED TEMPERATURE (T_A = 0°C TO 70°C) UNLESS OTHERWISE NOTED

Parameter	Symbol	Min.	Typ.**	Max.	Units	Test Conditions	Figure	Note
High Level Output Current	I_{OH}		2	250	μA	V_{CC} = 5.5V, V_O = 5.5V, I_F = 250μA		3
Low Level Output Voltage	V_{OL}		0.5	0.6	V	V_{CC} = 5.5V, I_F = 5mA I_{OL} (Sinking) = 13mA	3	3
High Level Supply Current	I_{CCH}		14	30	mA	V_{CC} = 5.5V, I_F = 0 (Both Channels)		
Low Level Supply	I_{CCL}		28	36	mA	V_{CC} = 5.5V, I_F = 10mA (Both Channels)		
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 3 kV dc, T_A = 25°C		4,9
OPT 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50% t = 1 MIN		10
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	V_{I-O} = 500V, T_A = 25°C		4
Capacitance (Input-Output)	C_{I-O}		0.6		pF	f = 1MHz, T_A = 25°C		4
Input Forward Voltage	V_F		1.5	1.75	V	I_F = 10mA, T_A = 25°C	4	7,3
Input Reverse Breakdown Voltage	BV_R	5			V	I_R = 10μA, T_A = 25°C		
Input Capacitance	C_{IN}		60		pF	V_F = 0, f = 1MHz		3
Input-Input Insulation Leakage Current	I_{I-I}		0.005		μA	Relative Humidity = 45%, t=5s, V_{I-I}=500V		8
Resistance (Input-Input)	R_{I-I}		10^{11}		Ω	V_{I-I} = 500V		8
Capacitance (Input-Input)	C_{I-I}		0.25		pF	f = 1MHz		8
Current Transfer Ratio	CTR		700		%	I_F = 5.0mA, R_L = 100Ω	2	6

**All typical values are at V_{CC} = 5V, T_A = 25°C

Switching Characteristics at T_A=25°C, V_{CC}=5V

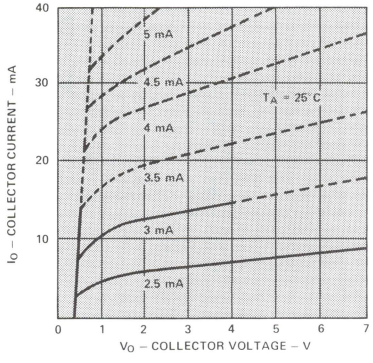
EACH CHANNEL

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Propagation Delay Time to High Output Level	t_{PLH}		55	75	ns	R_L = 350 Ω, C_L = 15pF, I_F = 7.5mA	6,7	1
Propagation Delay Time to Low Output Level	t_{PHL}		55	75	ns	R_L = 350 Ω, C_L = 15pF, I_F = 7.5mA	6,7	2
Pulse Width Distortion	$t_{PHL} - t_{PLH}$		10		ns	R_L = 350 Ω, C_L = 15pF, I_F = 7.5 mA		
Output Rise Time (10-90%)	t_r		50		ns	R_L = 350 Ω, C_L = 15pF, I_F = 7.5mA		
Output Fall Time (90-10%)	t_f		20		ns			
Common Mode Transient Immunity at High Output Level	$\|CM_H\|$		100		V/μs	V_{CM} = 10V_{p-p}, R_L = 350 Ω, V_O (min.) = 2V, I_F = 0mA	9	5
Common Mode Transient Immunity at Low Output Level	$\|CM_L\|$		300		V/μs	V_{CM} = 10V_{p-p}, R_L = 350 Ω, V_O (max.) = 0.8V I_F = 7.5mA	9	5

NOTE: It is essential that a bypass capacitor (.01μF to 0.1μF, ceramic) be connected from pin 8 to pin 5. Total lead length between both ends of the capacitor and the isolator pins should not exceed 20mm. Failure to provide the bypass may impair the switching properties (Figure 5).

NOTES:

1. The t_{PLH} propagation delay is measured from the 3.75 mA point on the trailing edge of the input pulse to the 1.5V point on the trailing edge of the output pulse.
2. The t_{PHL} propagation delay is measured from the 3.75 mA point on the leading edge of the input pulse to the 1.5V point on the leading edge of the output pulse.
3. Each channel.
4. Measured between pins 1, 2, 3, and 4 shorted together, and pins 5, 6, 7, and 8 shorted together.
5. Common mode transient immunity in Logic High level is the maximum tolerable (positive) dV_{CM}/dt on the leading edge of the common mode pulse, V_{CM}, to assure that the output will remain in a Logic High state (i.e., $V_O > 2.0V$). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) dV_{CM}/dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a Logic Low state (i.e., $V_O < 0.8V$).
6. DC Current Transfer Ratio is defined as the ratio of the output collector current to the forward bias input current times 100%.
7. At 10mA VF decreases with increasing temperature at the rate of 1.6mV/°C.
8. Measured between pins 1 and 2 shorted together, and pins 3 and 4 shorted together.
9. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
10. See Option 010 data sheet for more information.



NOTE: Dashed characteristics indicate pulsed operation.

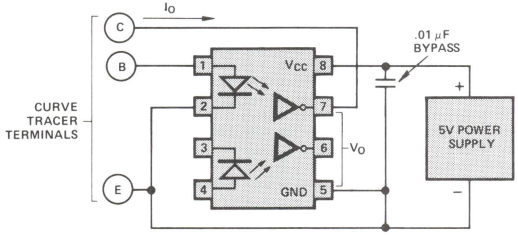
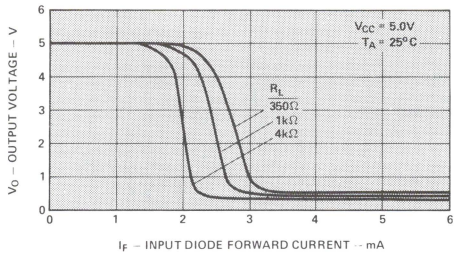


Figure 2. Optocoupler Transfer Characteristics.



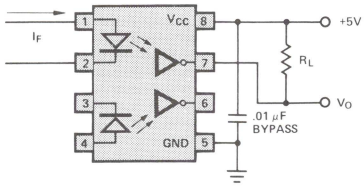


Figure 3. Input-Output Characteristics.

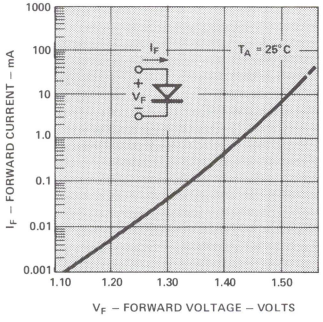


Figure 4. Input Diode Forward Characteristic

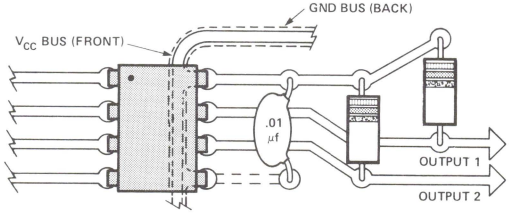
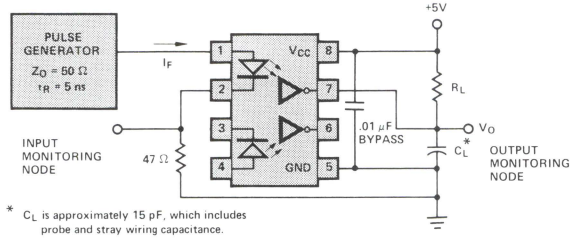


Figure 5. Recommended Printed Circuit Board Layout.



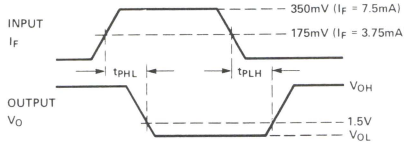


Figure 6. Test Circuit for t_{PHL} and t_{PLH}.

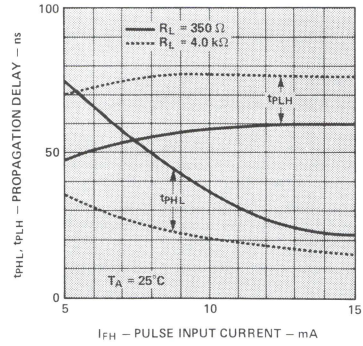


Figure 7. Propagation Delay, t_{PHL} and t_{PLH} vs. Pulse Input Current, I_{FH}.

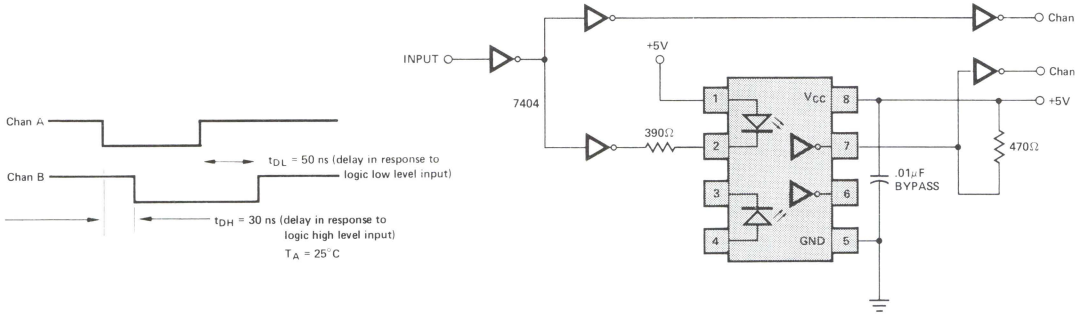


Figure 8. Response Delay Between TTL Gates.

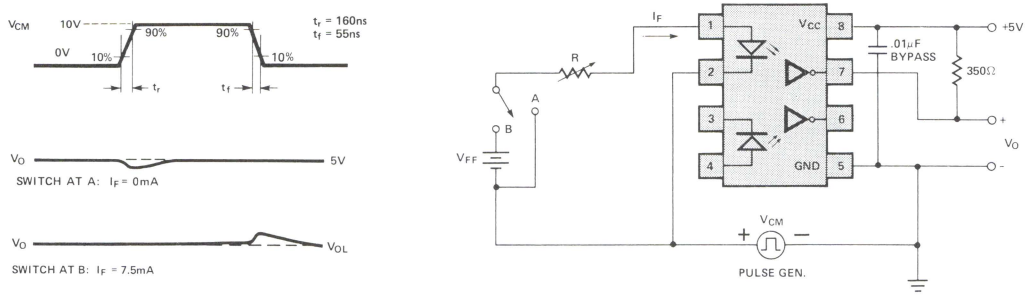


Figure 9. Test Circuit for Transient Immunity and Typical Waveforms.

HEWLETT PACKARD

DUAL CHANNEL HIGH CMR HIGH SPEED OPTOCOUPLER

HCPL-2631
HCPL-4661

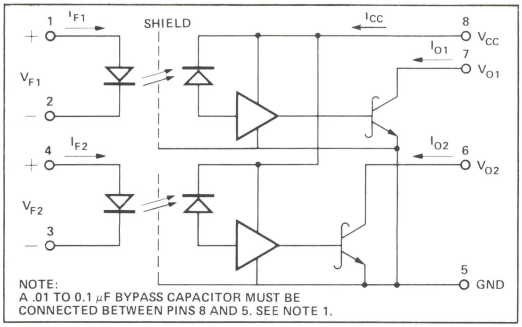
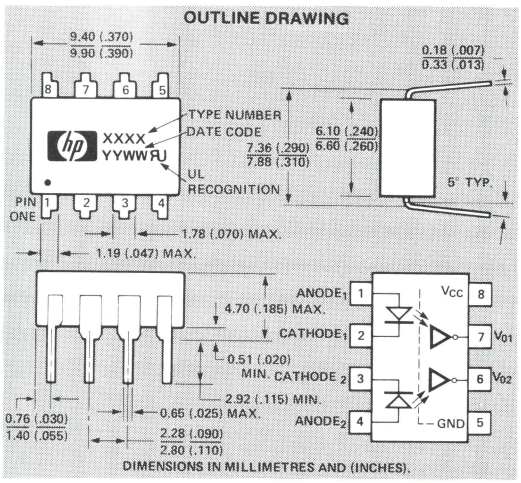


Figure 1. Schematic



Features

- **INTERNAL SHIELD FOR HIGH COMMON MODE REJECTION (CMR)**

  2631 = 1000 V/μs

  4661 = 3500 V/μs
- **HIGH DENSITY PACKAGING**
- **HIGH SPEED: 10 MBd TYPICAL**
- **LSTTL AND TTL COMPATIBLE**
- **GUARANTEED PERFORMANCE OVER TEMPERATURE 0°C to 70°C**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**
- **6N134 COMPATIBILITY**

Description

The HCPL-2631/4661 are dual channel optically coupled logic gates that combine GaAsP light emitting diodes and integrated high gain photodetectors. Internal shields provide a guaranteed common mode transient immunity specification of 1000 V/μs with the HCPL-2631, and 3500 V/μs with the HCPL-4661. The unique design provides maximum DC and AC circuit isolation while achieving LSTTL and TTL logic compatibility. The logic isolation is achieved with a typical propagation delay of 40 nsec. The dual channel design saves space and results in increased convenience.

The HCPL-2631/4661 are recommended for high speed logic interfacing, input/output buffering and for use as line receivers in environments that conventional line receivers cannot tolerate. The HCPL-2631/4661 can be used for the digital programming of machine control systems, motors, and floating power supplies. The internal shield makes the HCPL-2631/4661 ideal for use in extremely high ground or induced noise environments.

Applications

- **ISOLATION OF HIGH SPEED LOGIC SYSTEMS**
- **MICROPROCESSOR SYSTEM INTERFACES**
- **ISOLATED LINE RECEIVER**
- **COMPUTER—PERIPHERAL INTERFACES**
- **GROUND LOOP ELIMINATION**
- **DIGITAL ISOLATION FOR A/D, D/A CONVERSION**

Recommended Operating Conditions

	Sym.	Min.	Max.	Units
Input Current, Low Level Each Channel	I_{FL}	0	250	μA
Input Current, High Level Each Channel	I_{FH}	6.3*	15	mA
Supply Voltage, Output	V_{CC}	4.5	5.5	V
Fan Out (TTL Load) Each Channel	N		8	
Operating Temperature	T_A	0	70	°C

*6.3 mA condition permits at least 20% CTR degradation guardband. Initial switching threshold is 5 mA or less.

OPTOCOUPLERS

Absolute Maximum Ratings

(No derating required up to 70° C)

Storage Temperature ..... −55° C to +125° C

Operating Temperature ..... 0° C to +70° C

Lead Solder Temperature ..... 260° C for 10s (1.6 mm below seating plane)

Average Forward Input Current (each channel) ..... 15 mA (See Note 2)

Reverse Input Voltage (each channel) ..... 5 V

Supply Voltage — V_{CC} ..... 7 V (1 Minute Maximum)

Output Current — I_O (each channel) ..... 16 mA

Output Voltage — V_O (each channel) ..... 7 V

Output Collector Power Dissipation (each channel) ..... 40 mW

Electrical Characteristics

(Over Recommended Temperature, T_A = 0° C to +70° C, Unless Otherwise Noted)

Parameter	Symbol	Min.	Typ.**	Max.	Units	Test Conditions	Figure	Note
Low Level Output Voltage	V_{OL}		0.4	0.6	V	V_{CC} = 5.5V, I_F = 5 mA I_{OL} (Sinking) = 13 mA	2, 3	3
High Level Output Current	I_{OH}		20	250	μA	V_{CC} = 5.5V, V_O = 5.5 V, I_F = 250 μA	4	3
High Level Supply Current	I_{CCH}		20	30	mA	V_{CC} = 5.5V, I_F = 0, (Both Channels)		
Low Level Supply Current	I_{CCL}		30	38	mA	V_{CC} = 5.5V, I_F = 10 mA, (Both Channels)		
Input Forward Voltage	V_F		1.5	1.75	V	I_F = 10 mA, T_A = 25° C	5	3
Input Reverse Breakdown Voltage	BV_R	5			V	I_R = 10 μA, T_A = 25° C		3
Input Capacitance	C_{IN}		60		pF	V_F = 0, f = 1 MHz		3
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		−1.6		mV/° C	I_F = 10 mA		
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 3 kV dc, T_A = 25° C		4, 5
OPT 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50% t = 1 MIN		13
Input-Input Leakage Current	I_{I-I}		0.005		μA	Relative Humidity = 45% t = 5 s, V_{I-I} = 500 V		6
Resistance (Input-Input)	R_{I-I}		10^{11}		Ω	V_{I-I} = 500 V		6
Capacitance (Input-Input)	C_{I-I}		0.25		pF	f = 1 MHz		
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	V_{I-O} = 500 V		4
Capacitance (Input-Output)	C_{I-O}		0.6		pF	f = 1 MHz		

** All typical values are at V_{CC} = 5 V, T_A = 25° C.

Switching Characteristics (T_A = 25° C, V_{CC} = 5 V)

Parameter	Symbol		Min.	Typ.	Max.	Units	Test Conditions		Figure	Note
Propagation Delay Time to High Output Level	t_{PLH}			40	75	ns			6	3, 7
Propagation Delay Time to Low Output Level	t_{PHL}			40	75	ns	R_L = 350 Ω C_L = 15 pF		6	3, 8
Pulse Width Distortion	$\lvert t_{PHL}-t_{PLH}\rvert$			10		ns	I_F = 7.5 mA			
Output Rise Time (10-90%)	t_r			20		ns				3
Output Fall Time (90-10%)	t_f			30		ns				3
Common Mode Transient Immunity at High Output Level	$\lvert CM_H\rvert$	2631	1000	10,000		V/μs	V_{CM} = 50 V	$V_{O(MIN)}$ = 2 V R_L = 350 Ω I_F = 0 mA	10	3, 9 11
		4661	3500			V/μs	V_{CM} = 400 V			
Common Mode Transient Immunity at Low Output Level	$\lvert CM_L\rvert$	2631	1000	10,000		V/μs	V_{CM} = 50 V	$V_{O(MAX)}$ = 0.8 V R_L = 350 Ω I_F = 7.5 mA	10	3, 10 11
		4661	3500			V/μs	V_{CM} = 400 V			

NOTES:

1. Bypassing of the power supply line is required, with a 0.01 μF ceramic disc capacitor adjacent to each isolator as illustrated in Figure 14. Total lead length between both ends of the capacitor and the isolator pins should not exceed 20 mm. The power supply bus for the isolator(s) should be separate from the bus for any active loads, otherwise a larger value of bypass capacitor (up to 0.1 μF) may be needed to suppress regenerative feedback via the power supply. Failure to provide the bypass may impair the switching properties.
2. Peaking circuits may produce transient input currents up to 50 mA, 50 ns maximum pulse width, provided average current does not exceed 15 mA.
3. Each channel.
4. Measured between pins 1, 2, 3, and 4 shorted together, and pins 5, 6, 7, and 8 shorted together.
5. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
6. Measured between pins 1 and 2 shorted together, and pins 3 and 4 shorted together.
7. The t_{PLH} propagation delay is measured from the 3.75 mA point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
8. The t_{PHL} propagation delay is measured from the 3.75 mA point on the leading edge of the input pulse to the 1.5 V point on the leading edge of the output pulse.
9. CM_H is the maximum tolerable rate of rise of the common mode voltage to assure that the output will remain in a high logic state (i.e., $V_{OUT} > 2.0$ V).
10. CM_L is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state (i.e., $V_{OUT} < 0.8$ V).
11. For sinusoidal voltages, $\left(\frac{|dv_{CM}|}{dt}\right)_{max} = \pi f_{CM} V_{CM}$ (p-p)
12. As illustrated in Figure 14, the V_{CC} and GND traces can be located between the input and the output leads of the HCPL-2631/4661 to provide additional noise immunity at the compromise of insulation capability.
13. See Option 010 data sheet for more information.

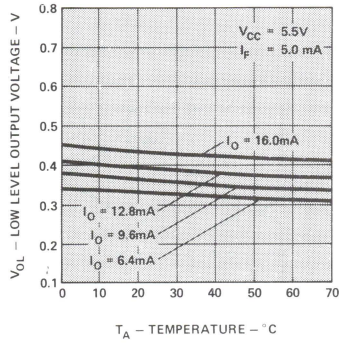


Figure 2. Low Level Output Voltage vs. Temperature

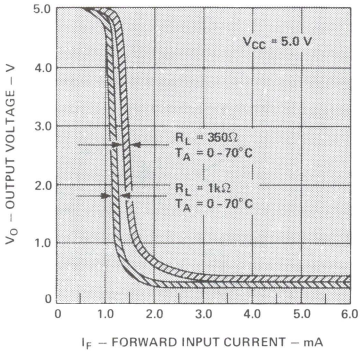


Figure 3. Output Voltage vs. Forward Input Current

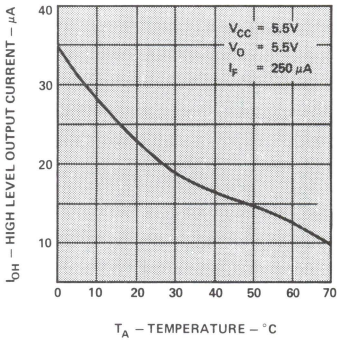


Figure 4. High Level Output Current vs. Temperature

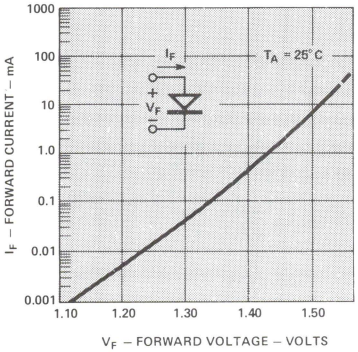


Figure 5. Input Diode Forward Characteristic

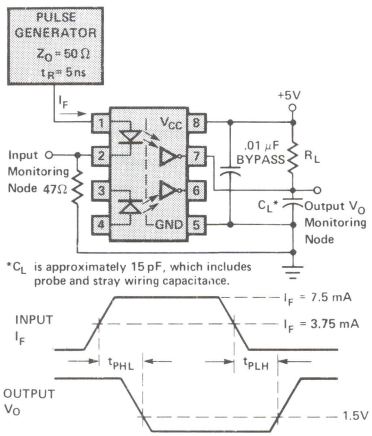


Figure 6. Test Circuit for t_{PHL} and t_{PLH}. Note 3

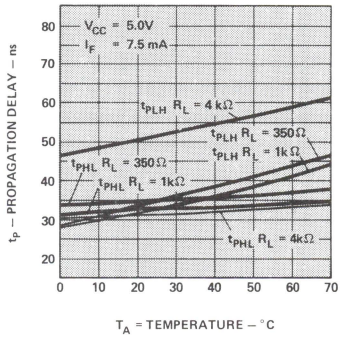


Figure 7. Propagation Delay vs. Temperature

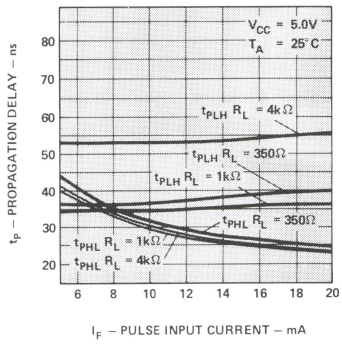


Figure 8. Propagation Delay vs. Pulse Input Current

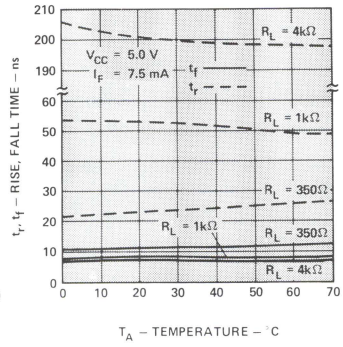


Figure 9. Rise, Fall Time vs. Temperature

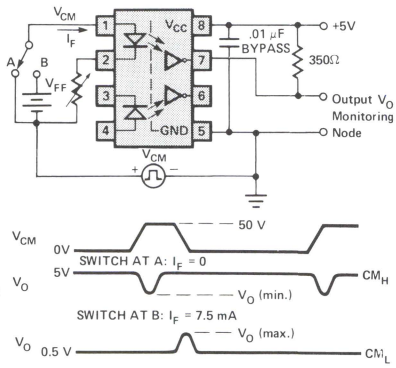


Figure 10. Test Circuit for Common Mode Transient Immunity and Typical Waveforms. Note 3

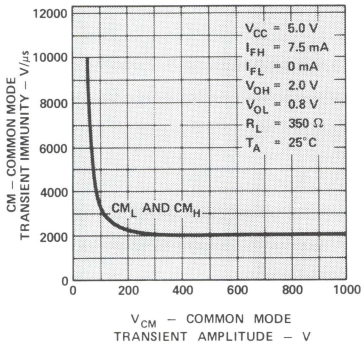
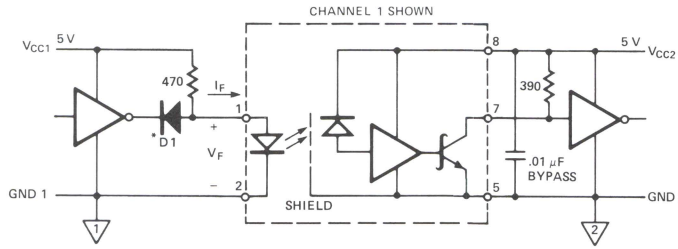


Figure 11. Common Mode Transient Immunity vs. Common Mode Transient Amplitude



*DIODE D1 (1N916 OR EQUIVALENT) IS NOT REQUIRED FOR UNITS WITH OPEN COLLECTOR OUTPUT.

Figure 12. Recommended TTL/LSTTL to TTL/LSTTL Interface Circuit

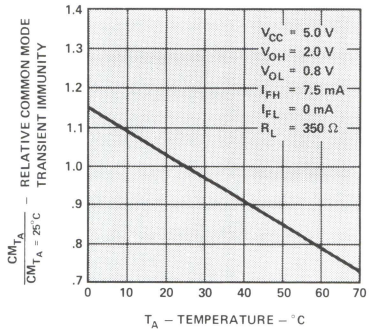


Figure 13. Relative Common Mode Transient Immunity vs. Temperature

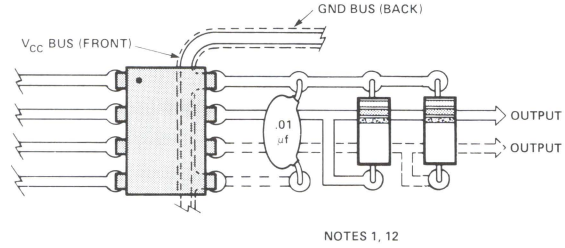
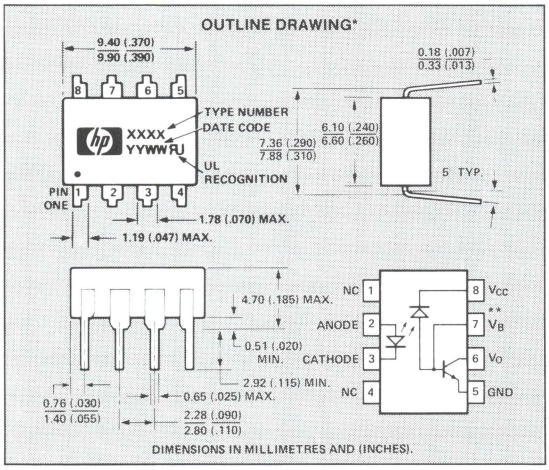


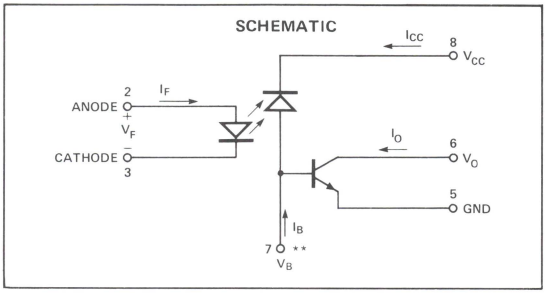
Figure 14. Recommended Printed Circuit Board Layout

HEWLETT PACKARD

HIGH SPEED OPTOCOUPLERS

6N135
6N136
HCPL-2502
HCPL-4502





Note: For HCPL-4502, pin 7 is not connected.

Features

- **HIGH SPEED: 1 Mbit/s**
- **TTL COMPATIBLE**
- **HIGH COMMON MODE TRANSIENT IMMUNITY: >1000V/μs TYPICAL**
- **9 MHz BANDWIDTH**
- **OPEN COLLECTOR OUTPUT**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**

Description

These diode-transistor optocouplers use an insulating layer between the light emitting diode and an integrated photon detector to provide electrical insulation between input and output. Separate connection for the photodiode bias and output transistor collector increases the speed up to a hundred times that of a conventional photo-transistor coupler by reducing the base-collector capacitance.

The 6N135 is for use in TTL/CMOS, TTL/LSTTL or wide bandwidth analog applications. Current transfer ratio (CTR) for the 6N135 is 7% minimum at I_F = 16 mA.

The 6N136 is designed for high speed TTL/TTL applications. A standard 16 mA TTL sink current through the input LED will provide enough output current for 1 TTL load and a 5.6 kΩ pull-up resistor. CTR of the 6N136 is 19% minimum at I_F = 16 mA.

The HCPL-2502 is suitable for use in applications where matched or known CTR is desired. CTR is 15 to 22% at I_F = 16 mA.

The HCPL-4502 provides the electrical and switching performance of the 6N136 and increased ESD protection.

*JEDEC Registered Data (The HCPL-2502 and HCPL-4502 are not registered.)

Applications

- **Video Signal Isolation**
- **Line Receivers** — High common mode transient immunity (>1000V/μs) and low input-output capacitance (0.6pF).
- **High Speed Logic Ground Isolation** — TTL/TTL, TTL/LTTL, TTL/CMOS, TTL/LSTTL.
- **Replace Slow Phototransistor Isolators** — Pins 2-7 of the 6N135/6 series conform to pins 1-6 of 6 pin phototransistor couplers. Pin 8 can be tied to any available bias voltage of 1.5V to 30V for high speed operation.
- **Replace Pulse Transformers** — Save board space and weight.
- **Analog Signal Ground Isolation** — Integrated photon detector provides improved linearity over phototransistor type.

Absolute Maximum Ratings

Storage Temperature* ..... −55°C to +125°C
Operating Temperature* ..... −55°C to 100°C
Lead Solder Temperature* ..... 260°C for 10s
(1.6mm below seating plane)
Average Input Current — I_F* ..... 25mA[1]
Peak Input Current — I_F* ..... 50mA[2]
(50% duty cycle, 1 ms pulse width)
Peak Transient Input Current — I_F* 1.0A
(≤1μs pulse width, 300pps)
Reverse Input Voltage — V_R* (Pin 3-2) 5V
Input Power Dissipation* ..... 45mW[3]
Average Output Current — I_O* (Pin 6) 8mA
Peak Output Current* 16mA
Emitter-Base Reverse Voltage* (Pin 5-7, except −4502) ... 5V
Output Voltage* — V_O (Pin 6-5) ..... −0.5V to 15V
Supply Voltage* — V_{CC} (Pin 8-5) ..... −0.5V to 15V
Output Voltage — V_O (Pin 6-5) ..... −0.5V to 20V
Supply Voltage — V_{CC} (Pin 8-5) ..... −0.5V to 30V
Base Current — I_B* (Pin 7, except HCPL-4502) 5mA
Output Power Dissipation* ..... 100mW[4]

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

See notes, following page.

Electrical Specifications Over recommended temperature (T_A = 0°C to 70°C) unless otherwise specified.

Parameter	Sym.	Device	Min.	Typ.**	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR*	6N135	7	18		%	I_F = 16mA, V_O = 0.4V, V_{CC} = 4.5V, T_A = 25°C	1,2,4	5,12
		6N136 HCPL-4502	19	24		%			
		HCPL-2502	15	18	22	%			
	CTR	6N135	5	19		%	I_F = 16mA, V_O = 0.5V, V_{CC} = 4.5V		5
		6N136 HCPL-4502	15	25		%			
Logic Low Output Voltage	V_{OL}	6N135		0.1	0.4	V	I_F = 16 mA, I_O = 1.1mA, V_{CC} = 4.5V, T_A = 25°C		
		6N136 HCPL-2502 HCPL-4502		0.1	0.4	V	I_F = 16mA, I_O = 2.4mA, V_{CC} = 4.5V, T_A = 25°C		
Logic High Output Current	I_{OH}*			3	500	nA	I_F = 0mA, V_O = V_{CC} = 5.5V, T_A = 25°C	6	
				0.01	1	μA	I_F = 0mA, V_O = V_{CC} = 15V, T_A = 25°C		
	I_{OH}				50	μA	I_F = 0mA, V_O = V_{CC} = 15V		
Logic Low Supply Current	I_{CCL}			50		μA	I_F = 16mA, V_O = Open, V_{CC} = 15V		
Logic High Supply Current	I_{CCH}*			0.02	1	μA	I_F = 0mA, V_O = Open, V_{CC} = 15V, T_A = 25°C		
	I_{CCH}				2	μA	I_F = 0mA, V_O = Open, V_{CC} = 15V		
Input Forward Voltage	V_F*			1.5	1.7	V	I_F = 16mA, T_A = 25°C	3	
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$			-1.6		mV/°C	I_F = 16mA		
Input Reverse Breakdown Voltage	BV_R*		5			V	I_R = 10μA, T_A = 25°C		
Input Capacitance	C_{IN}			60		pF	f = 1MHz, V_F = 0		
Input-Output Insulation	I_{I-O}*				1	μA	45% RH, t = 5s, V_{I-O} = 3kV dc, T_A = 25°C		6, 11
OPT. 010	V_{ISO}		2500			V_{RMS}	RH ≤ 50%, t = 1 min.		13
Resistance (Input-Output)	R_{I-O}			10^{12}		Ω	V_{I-O} = 500Vdc		6
Capacitance (Input-Output)	C_{I-O}			0.6		pF	f = 1MHz		6
Transistor DC Current Gain	h_{FE}			150		—	V_O = 5V, I_O = 3mA		

*For JEDEC registered parts. **All typicals at T_A = 25°C

Switching Specifications at T_A = 25°C V_{CC} = 5V, I_F = 16mA, unless otherwise specified

Parameter	Sym.	Device	Min.	Typ.**	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time to Logic Low at Output	t_{PHL}*	6N135		0.2	1.5	μs	R_L = 4.1kΩ	5,9	8,9
		6N136 HCPL-2502 HCPL-4502		0.2	0.8	μs	R_L = 1.9kΩ		
Propagation Delay Time to Logic High at Output	t_{PLH}*	6N135		1.3	1.5	μs	R_L = 4.1kΩ	5,9	8,9
		6N136 HCPL-2502 HCPL-4502		0.6	0.8	μs	R_L = 1.9kΩ		
Common Mode Transient Immunity at Logic High Level Output	$\lvert CM_H \rvert$	6N135		1000		V/μs	I_F = 0mA, V_{CM} = 10 V_{p-p}, R_L = 4.1kΩ	10	7,8,9
		6N136 HCPL-2502 HCPL-4502		1000		V/μs	I_F = 0 m, V_{CM} = 10 V_{p-p}, R_L = 1.9kΩ		
Common Mode Transient Immunity at Logic Low Level Output	$\lvert CM_L \rvert$	6N135		1000		V/μs	V_{CM} = 10V_{p-p}, R_L = 4.1kΩ	10	7,8,9
		6N136 HCPL-2502 HCPL-4502		1000		V/μs	V_{CM} = 10V_{p-p}, R_L = 1.9kΩ		
Bandwidth	BW			9		MHz	See Test Circuit	8	10

Notes:

1. Derate linearly above 70° C free-air temperature at a rate of 0.8 mA/°C.
2. Derate linearly above 70° C free-air temperature at a rate of 1.6 mA/°C.
3. Derate linearly above 70° C free-air temperature at a rate of 0.9 mW/°C.
4. Derate linearly above 70° C free-air temperature at a rate of 2.0 mW/°C.
5. CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
6. Device considered a two-terminal device: Pins 1, 2, 3, and 4 shorted together and Pins 5, 6, 7, and 8 shorted together.
7. Common mode transient immunity in Logic High level is the maximum tolerable (positive) dv_{CM}/dt on the leading edge of the common mode pulse, V_{CM}, to assure that the output will remain in a Logic High state (i.e., V_O > 2.0 V). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) dV_{CM}/dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a Logic Low state (i.e., V_O < 0.8 V).
8. The 1.9 kΩ load represents 1 TTL unit load of 1.6 mA and the 5.6 kΩ pull-up resistor.
9. The 4.1 kΩ load represents 1 LSTTL unit load of 0.36 mA and 6.1 kΩ pull-up resistor.
10. The frequency at which the ac output voltage is 3 dB below its maximum value.
11. The is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
12. The JEDEC registration for the 6N136 specifies a minimum CTR of 15%. HP guarantees a minimum CTR of 19%.
13. See Option 010 data sheet for more information.

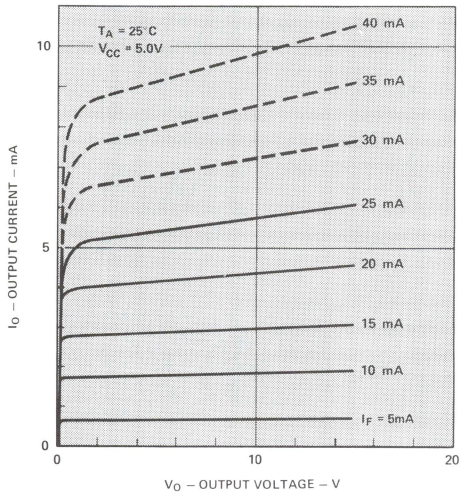


Figure 1. DC and Pulsed Transfer Characteristics.

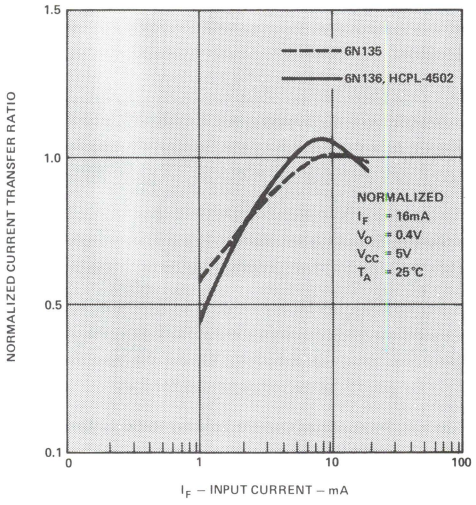


Figure 2. Current Transfer Ratio vs. Input Current.

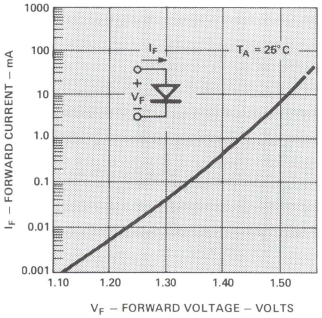


Figure 3. Input Current vs. Forward Voltage.

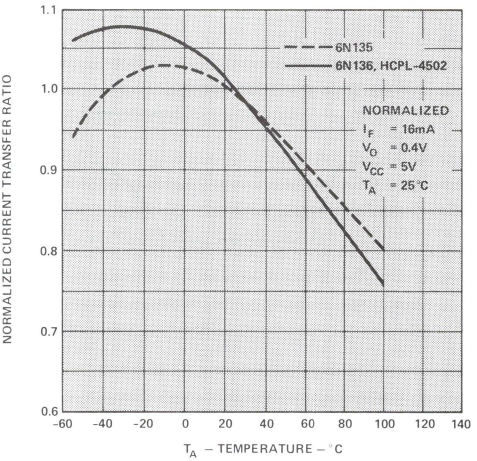


Figure 4. Current Transfer Ratio vs. Temperature.

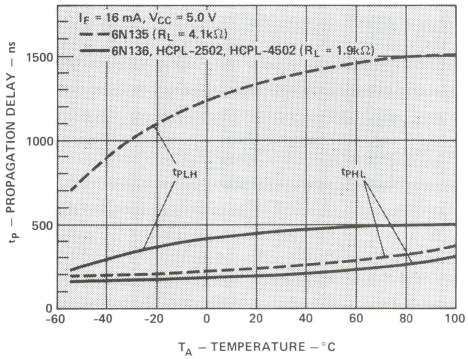


Figure 5. Propagation Delay vs. Temperature.

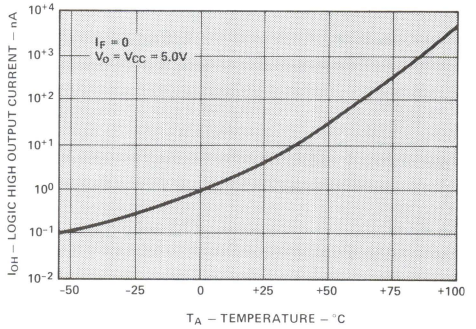


Figure 6. Logic High Output Current vs. Temperature.

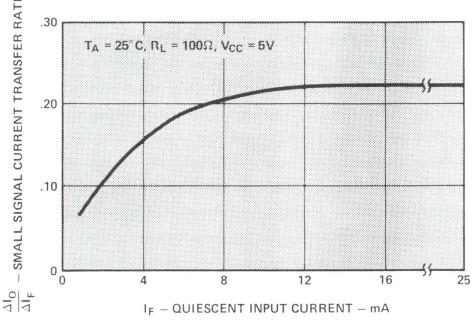
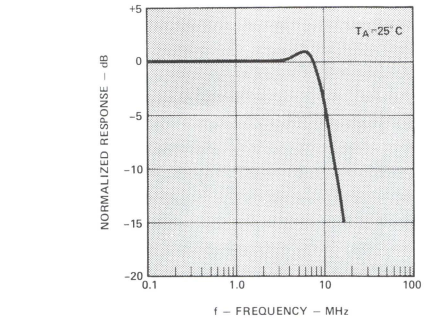
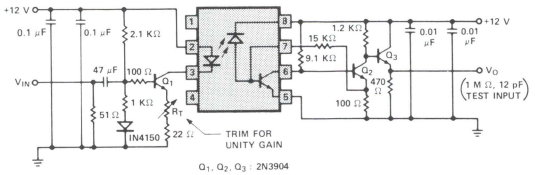


Figure 7. Small-Signal Current Transfer Ratio vs. Quiescent Input Current.





TYPICAL LINEARITY = +/– 3% AT V_{IN} = 1 V_{p-p}
TYPICAL SNR = 50 dB
TYPICAL R_T = 375 Ω
TYPICAL V_O dc = 3.8 V
TYPICAL I_F = 9 mA

Figure 8. Frequency Response.

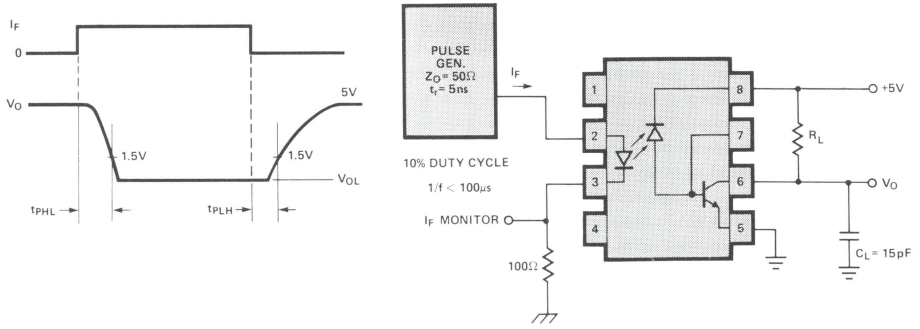
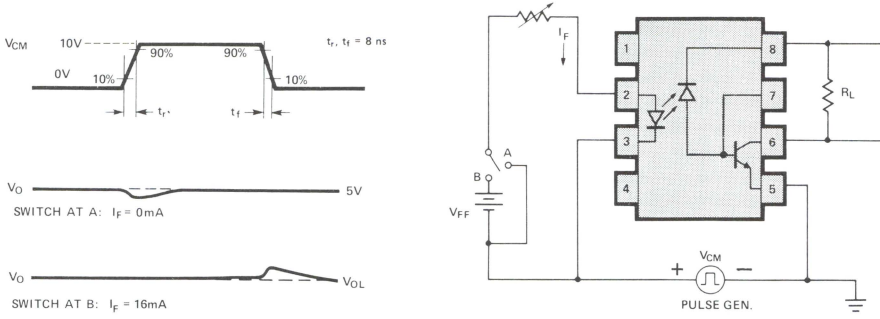


Figure 9. Switching Test Circuit. *



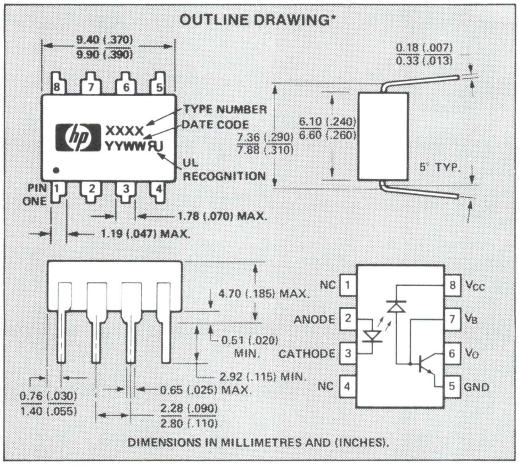
*JEDEC Registered Data

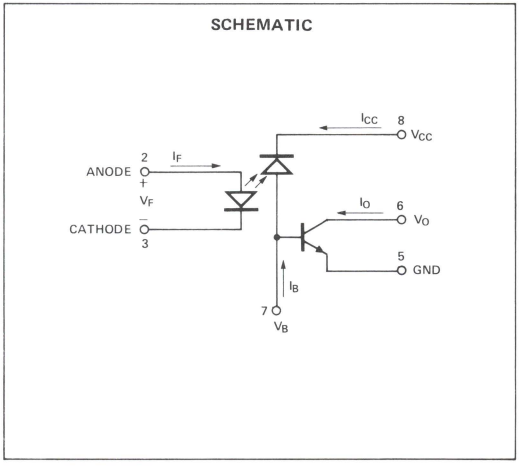
Figure 10. Test Circuit for Transient Immunity and Typical Waveforms.

HEWLETT PACKARD

HIGH SPEED OPTOCOUPLER

SL5505





Absolute Maximum Ratings

Storage Temperature ..... -55°C to +125°C
Operating Temperature ..... -55°C to 100°C
Lead Solder Temperature ..... 260°C for 10s
(1.6mm below seating plane)
Average Input Current — I_F ..... 25mA[1]
Peak Input Current — I_F ..... 50mA[2]
(50% duty cycle, 1 ms pulse width)
Peak Transient Input Current — I_F 1.0A
(≤1μs pulse width, 300pps)
Reverse Input Voltage — V_R (Pin 3-2) 3V
Input Power Dissipation ..... 45mW[3]
Average Output Current — I_O (Pin 6) 8mA
Peak Output Current 16mA
Emitter-Base Reverse Voltage (Pin 5-7) 5V
Supply and Output Voltage — V_{CC} (Pin 8-5),
V_O (Pin 6-5) ..... -0.5V to 15V
Base Current — I_B (Pin 7) 5mA
Output Power Dissipation ..... 100mW[4]

Switching Specifications at T_A=25°C

V_{CC} = 5V, I_F = 16mA, unless otherwise specified

Parameter	Symbol	Min.	Max.	Units	Test Conditions	Note
Propagation Delay Time to Logic Low at Output (Fig. 1)	t_{PHL}		0.8	μs	R_L = 1.9kΩ	7
Propagation Delay Time to Logic High at Output (Fig. 1)	t_{PLH}		0.8	μs	R_L = 1.9kΩ	7

Electrical Specifications ($T_A = 25°C$) unless otherwise specified.

Parameter	Symbol	Min.	Max.	Units	Test Conditions	Note
Current Transfer Ratio	CTR	15	40	%	$I_F = 16mA$, $V_O = 0.4V$, $V_{CC} = 4.5V$	5
	CTR	8		%	$I_F = 2mA$, $V_O = 5.0V$, $V_{CC} = 4.5V$	
Logic Low Output Voltage	V_{OL}		0.4	V	$I_F = 16mA$, $I_O = 2.4mA$, $V_{CC} = 4.5V$	
Logic High Output Current	I_{OH}		50	nA	$I_F = 0mA$, $V_O = V_{CC} = 10V$	
	I_{OH}		25	μA	$I_F = 0mA$, $V_O = V_{CC} = 10V$, $T_A = 70°C$	
Input Forward Voltage	V_F		1.8	V	$I_F = 20mA$	
Input Reverse Current	I_R		50	μA	$V_R = 3V$	
Input-Output Insulation Leakage Current	I_{I-O}		1.0	μA	45% Relative Humidity, t = 5s $V_{I-O} = 1500Vdc$	6
Resistance (Input-Output)	R_{I-O}	10^9		Ω	$V_{I-O} = 100Vdc$	6
Transistor DC Current Gain	h_{FE}	100	400	—	$V_O = 5V$, $I_O = 3mA$	
Capacitance	C_{I-O}		1.3	pF	f = 1 MHz	6
Breakdown Voltage Collector/Emitter	$V_{(BR)}$ CEO	22		V	$I_C = 10mA$	8
Breakdown Voltage Collector/Base	$V_{(BR)}$ CBO	40		V	$I_C = 10\mu A$	
Breakdown Voltage Emitter/Base	$V_{(BR)}$ EBO	3		V	$I_E = 10\mu A$	
Collector/Base Current	I_{CBO}		50	nA	$V_{CB} = 22V$	

Notes:
1. Derate linearly above 70°C free-air temperature at a rate of 0.8mA/ °C.
2. Derate linearly above 70°C free-air temperature at a rate of 1.6mA/ °C.
3. Derate linearly above 70°C free-air temperature at a rate of 0.9mW/°C.
4. Derate linearly above 70°C free-air temperature at a rate of 2.0mW/°C.
5. CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
6. Device considered a two-terminal device: Pins 1, 2, 3, and 4 shorted together and Pins 5, 6, 7, and 8 shorted together.
7. The 1.9 KΩ load represents 1 TTL unit load of 1.6 mA and the 5.6 KΩ pull-up resistor.
8. Duration of this test should not exceed 300 μs.

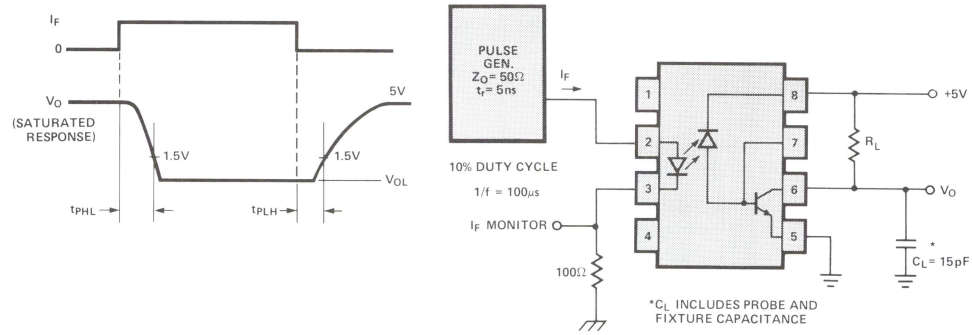


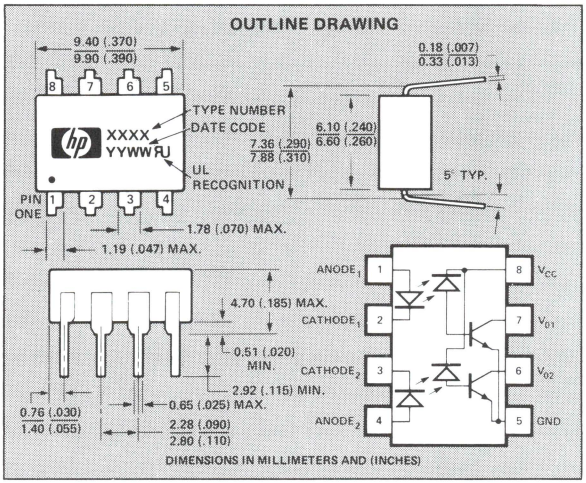
Figure 1. Switching Test Circuit.

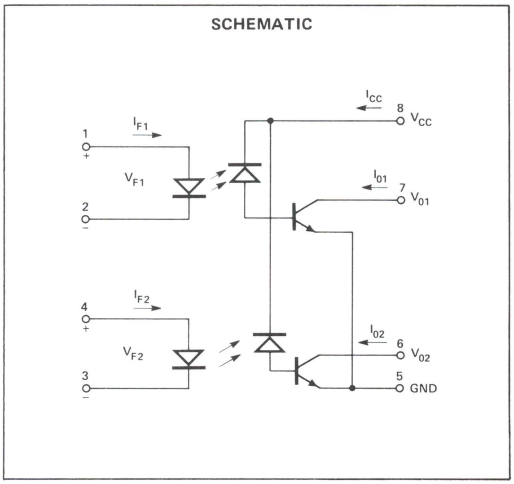
CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

HEWLETT PACKARD

DUAL HIGH SPEED OPTOCOUPLER

HCPL-2530
HCPL-2531





Features

- **HIGH SPEED: 1 Mbit/s**
- **TTL COMPATIBLE**
- **HIGH COMMON MODE TRANSIENT IMMUNITY: > 1000V/μs TYPICAL**
- **HIGH DENSITY PACKAGING**
- **3 MHz BANDWIDTH**
- **OPEN COLLECTOR OUTPUTS**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**
- **4N55 COMPATIBILITY**

Description

The HCPL-2530/31 dual couplers contain a pair of light emitting diodes and integrated photon detectors with electical insulation between input and output. Separate connection for the photodiode bias and output transistor collectors increase the speed up to a hundred times that of a conventional phototransistor coupler by reducing the base-collector capacitance.

The HCPL-2530 is for use in TTL/CMOS, TTL/LSTTL or wide bandwidth analog applications. Current transfer ratio (CTR) for the -2530 is 7% minimum at I_F = 16 mA.

The HCPL-2531 is designed for high speed TTL/TTL applications. A standard 16 mA TTL sink current through the input LED will provide enough output curent for 1 TTL load and a 5.6 kΩ pull-up resistor. CTR of the -2531 is 19% minimum at I_F = 16 mA.

Applications

- **Line Receivers** — High common mode transient immunity (>1000V/μs) and low input-output capacitance (0.6pF).
- **High Speed Logic Ground Isolation** — TTL/TTL, TTL/LTTL, TTL/CMOS, TTL/LSTTL.
- **Replace Pulse Transformers** — Save board space and weight.
- **Analog Signal Ground Isolation** — Integrated photon detector provides improved linearity over phototransistor type.
- **Polarity Sensing.**
- **Isolated Analog Amplifier** — Dual channel packaging enhances thermal tracking.

Absolute Maximum Ratings

Storage Temperature . . . . . -55°C to +125°C
Operating Temperature . . . . . -55°C to +100°C
Lead Solder Temperature . . . . . 260°C for 10s
(1.6mm below seating plane)
Average Input Current — I_F (each channel) . . . . . 25mA [1]
Peak Input Current — I_F (each channel) . . . . . 50mA [2]
(50% duty cycle, 1 ms pulse width)
Peak Transient Input Current — I_F (each channel) . . . . 1.0 A
(≤1μs pulse width, 300pps)
Reverse Input Voltage — V_R (each channel) 5V
Input Power Dissipation (each channel) . . . . . 45mW [3]
Average Output Current — I_O (each channel) 8mA
Peak Output Current — I_O (each channel) 16mA
Supply Voltage - V_{CC} (Pin 8-5) . . . . . - 0.5V to 30V
Output Voltage - V_O (Pin 7,6-5) . . . . . - 0.5V to 20V
Output Power Dissipation (each channel) . . . . . 35mW [4]

See notes, following page.

Electrical Specifications

Over recommended temperature (T_A = 0°C to 70°C) unless otherwise specified.

Parameter	Sym.	Device HCPL-	Min.	Typ.**	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR	2530	7	18		%	I_F = 16mA, V_O = 0.5V, V_{CC} = 4.5V, T_A = 25°C	1,2	5,6
		2531	19	24		%			
		2530	5			%	I_F = 16mA, V_O = 0.5V, V_{CC} = 4.5V		
		2531	15			%			
Logic Low Output Voltage	V_{OL}	2530		0.1	0.5	V	I_F = 16mA, I_O = 1.1mA, V_{CC} = 4.5V, T_A = 25°C		5
		2531		0.1	0.5	V	I_F = 16mA, I_O = 2.4mA, V_{CC} = 4.5V, T_A = 25°C		
Logic High Output Current	I_{OH}			3	500	nA	T_A = 25°C, I_{F1} = I_{F2} = 0, V_{O1} = V_{O2} = V_{CC} = 5.5V	6	5
					50	µA	I_{F1} = I_{F2} = 0, V_{O1} = V_{O2} = V_{CC} = 15V		5
Logic Low Supply Current	I_{CCL}			100		µA	I_{F1} = I_{F2} = 16mA V_{O1} = V_{O2} = Open, V_{CC} = 15V		
Logic High Supply Current	I_{CCH}			0.05	4	µA	I_{F1} = I_{F2} = 0mA V_{O1} = V_{O2} = Open, V_{CC} = 15V		
Input Forward Voltage	V_F			1.5	1.7	V	I_F = 16mA, T_A = 25°C	3	5
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$			-1.6		mV/°C	I_F = 16mA		5
Input Reverse Breakdown Voltage	V_R		5			V	I_F = 10µA, T_A = 25°C		5
Input Capacitance	C_{IN}			60		pF	f = 1MHz, V_F = 0		5
Input-Output Insulation	I_{I-O}				1	µA	45% RH, t = 5s, V_{I-O} = 3kV dc, T_A = 25°C		7, 13
OPT. 010	V_{ISO}		2500			V_{RMS}	RH ≤ 50%, t = 1 min.		14
Resistance (Input-Output)	R_{I-O}			10^{12}		Ω	V_{I-O} = 500Vdc		7
Capacitance (Input-Output)	C_{I-O}			0.6		pF	f = 1MHz		7
Input-Input Insulation Leakage Current	I_{I-I}			0.005		µA	45% Relative Humidity, t = 5 s V_{I-I} = 500Vdc		8
Resistance (Input-Input)	R_{I-I}			10^{11}		Ω	V_{I-I} = 500Vdc		8
Capacitance (Input-Input)	C_{I-I}			0.25		pF	f = 1MHz		8

**All typicals at 25°C.

Switching Specifications at T_A=25°C V_{CC} = 5V, I_F = 16mA, unless otherwise specified

Parameter	Sym.	Device HCPL-	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time To Logic Low at Output	t_{PHL}	2530		0.2	1.5	µs	R_L = 4.1kΩ	5,9	10,11
		2531		0.2	0.8	µs	R_L = 1.9kΩ		
Propagation Delay Time to Logic High at Output	t_{PLH}	2530		1.3	1.5	µs	R_L = 4.1kΩ	5,9	10,11
		2531		0.6	0.8	µs	R_L = 1.9kΩ		
Common Mode Transient Immunity at Logic High Level Output	$\lvert CM_H \rvert$	2530		1000		V/µs	I_F = 0mA, R_L = 4.1kΩ, V_{CM} = $10V_{p-p}$	10	9,10,11
		2531		1000		V/µs	I_F = 0mA, R_L = 1.9kΩ, V_{CM} = $10V_{p-p}$		
Common Mode Transient Immunity at Logic Low Level Output	$\lvert CM_L \rvert$	2530		1000		V/µs	V_{CM} = $10V_{p-p}$, R_L = 4.1kΩ	10	9,10,11
		2531		1000		V/µs	V_{CM} = $10V_{p-p}$, R_L = 1.9kΩ		
Bandwidth	BW			3		MHz	R_L = 100Ω	8	12

NOTES:

1. Derate linearly above 70°C free-air temperature at a rate of 0.8mA/°C.
2. Derate linearly above 70°C free-air temperature at a rate of 1.6mA/°C.
3. Derate linearly above 70°C free-air temperature at a rate of 0.9mW/°C.
4. Derate linearly above 70°C free-air temperature at a rate of 1.0mW/°C.
5. Each channel.
6. CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
7. Device considered a two-terminal device: Pins 1, 2, 3, and 4 shorted together and Pins 5, 6, 7, and 8 shorted together.
8. Measured between pins 1 and 2 shorted together, and pins 3 and 4 shorted together.
9. Common mode transient immunity in Logic High level is the maximum tolerable (positive) dV_{CM}/dt on the leading edge of the common mode pulse V_{CM}, to assure that the output will remain in a Logic High state (i.e., V_O > 2.0V). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) dV_{CM}/dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a Logic Low state (i.e., V_O < 0.8V).
10. The 1.9kΩ load represents 1 TTL unit load of 1.6mA and the 5.6kΩ pull-up resistor.
11. The 4.1kΩ load represents 1 LSTTL unit load of 0.36mA and 6.1kΩ pull-up resistor.
12. The frequency at which the ac output voltage is 3dB below the low frequency asymptote.
13. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
14. See Option 010 data sheet for more information.

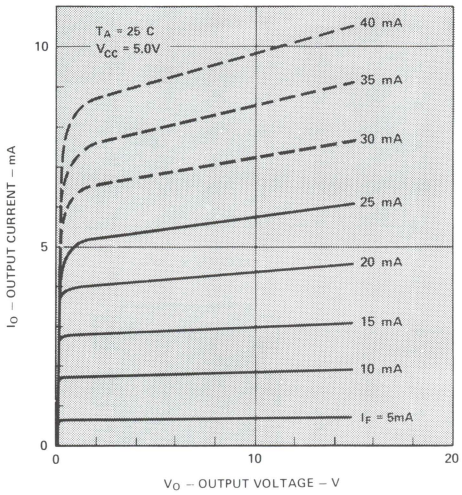


Figure 1. DC and Pulsed Transfer Characteristics.

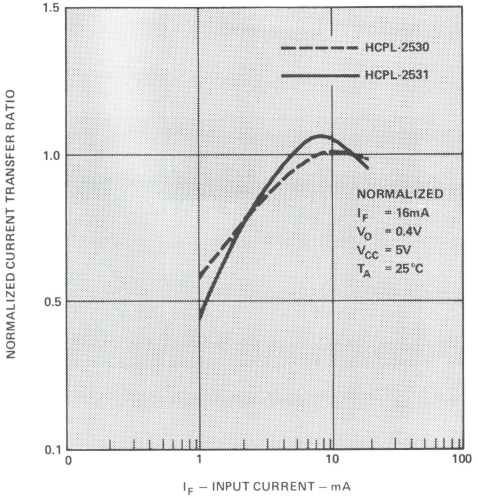


Figure 2. Current Transfer Ratio vs. Input Current.

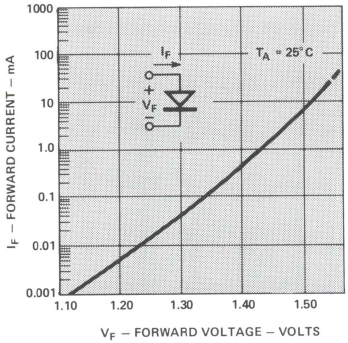


Figure 3. Input Current vs. Forward Voltage.

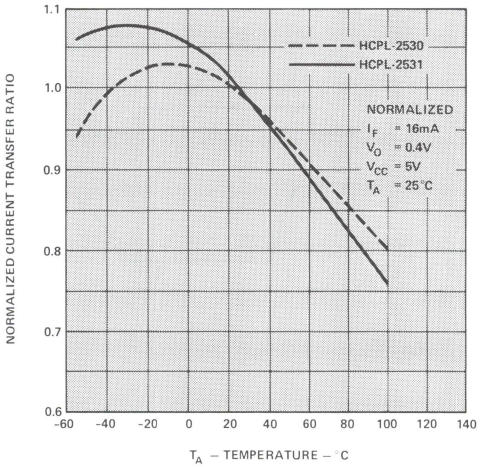


Figure 4. Current Transfer Ratio vs. Temperature.

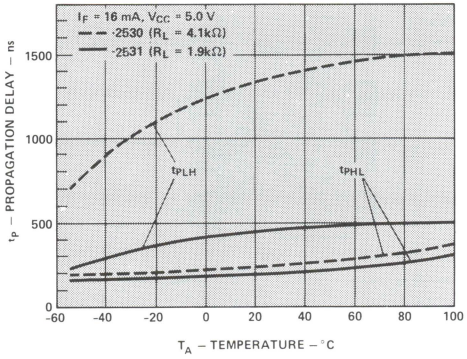


Figure 5. Propagation Delay vs. Temperature.

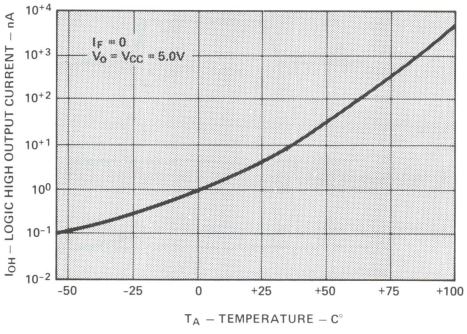


Figure 6. Logic High Output Current vs. Temperature.

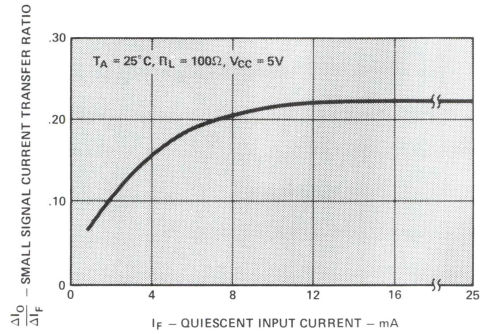


Figure 7. Small-Signal Current Transfer Ratio vs. Quiescent Input Current.

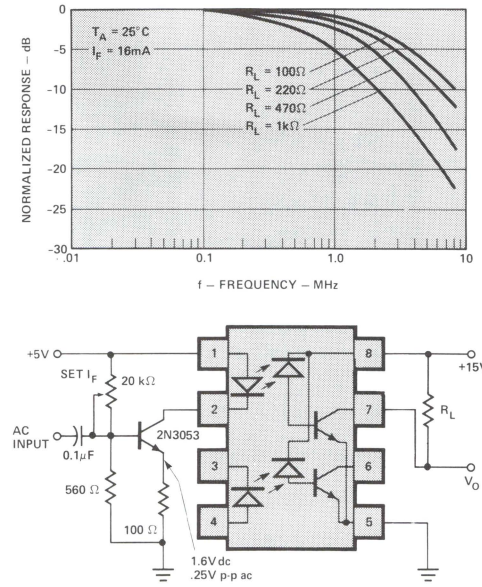


Figure 8. Frequency Response.

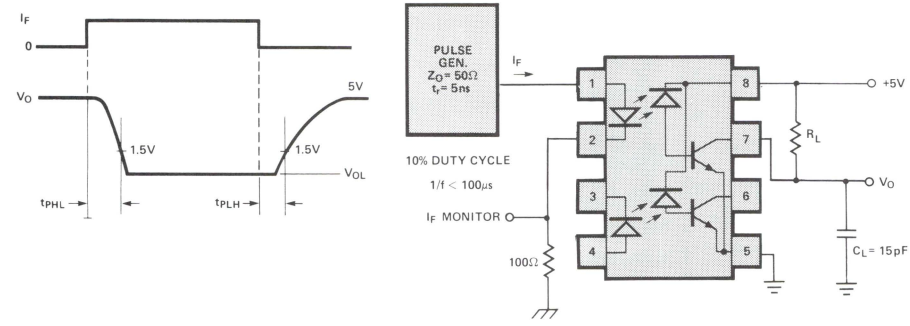


Figure 9. Switching Test Circuit.

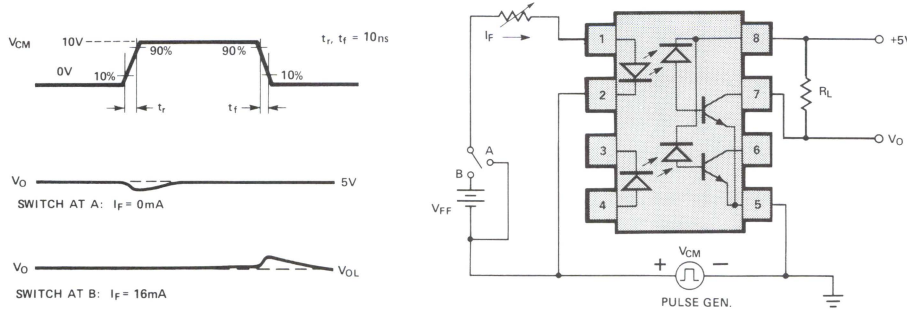
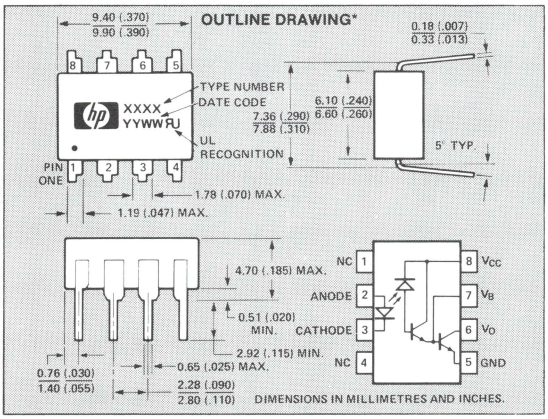


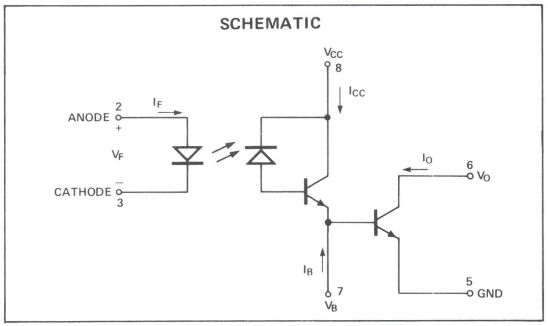
Figure 10. Test Circuit for Transient Immunity and Typical Waveforms.

HEWLETT PACKARD

LOW INPUT CURRENT, HIGH GAIN OPTOCOUPLERS

6N138
6N139





Features

- **HIGH CURRENT TRANSFER RATIO—2000% TYPICAL**
- **LOW INPUT CURRENT REQUIREMENT — 0.5 mA**
- **TTL COMPATIBLE OUTPUT — 0.1 V V_{OL} TYPICAL**
- **HIGH COMMON MODE REJECTION — 500 V/μs**
- **PERFORMANCE GUARANTEED OVER TEMPERATURE 0° C to 70° C**
- **BASE ACCESS ALLOWS GAIN BANDWIDTH ADJUSTMENT**
- **HIGH OUTPUT CURRENT — 60 mA**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**
- **HCPL-5700/1 COMPATIBILITY**

Description

These high gain series couplers use a Light Emitting Diode and an integrated high gain photon detector to provide extremely high current transfer ratio between input and output. Separate pins for the photodiode and output stage result in TTL compatible saturation voltages and high speed operation. Where desired the V_{CC} and V_O terminals may be tied together to achieve conventional photodarlington operation. A base access terminal allows a gain bandwidth adjustment to be made.

The 6N139 is for use in CMOS, LSTTL or other low power applications. A 400% minimum current transfer ratio is guaranteed over a 0-70° C operating range for only 0.5 mA of LED current.

The 6N138 is designed for use mainly in TTL applications. Current Transfer Ratio is 300% minimum over 0-70° C for an LED current of 1.6 mA [1 TTL Unit load (U.L.)]. A 300% minimum CTR enables operation with 1 U.L. out with a 2.2 kμ pull-up resistor.

Applications

- Ground Isolate Most Logic Families – TTL/TTL, CMOS/TTL, CMOS/CMOS, LSTTL/TTL, CMOS/LSTTL
- Low Input Current Line Receiver – Long Line or Party line
- EIA RS-232C Line Receiver
- Telephone Ring Detector
- 117 V ac Line Voltage Status Indicator – Low Input Power Dissipation
- Low Power Systems – Ground Isolation

Absolute Maximum Ratings*

Storage Temperature . . . . . −55°C to +125°C
Operating Temperature** . . . . . −40°C to +85°C
Lead Solder Temperature . . . . . 260°C for 10s
(1.6mm below seating plane)
Average Input Current – I_F . . . . . 20mA [1]
Peak Input Current – I_F 40mA
(50% duty cycle, 1 ms pulse width)
Peak Transient Input Current – I_F 1.0A
($\leq$ 1μs pulse width, 300 pps)
Reverse Input Voltage – V_R 5V
Input Power Dissipation . . . . . 35mW [2]
Output Current – I_O (Pin 6) . . . . . 60mA [3]
Emitter-Base Reverse Voltage (Pin 5-7) 0.5V
Supply and Output Voltage – V_{CC} (Pin 8-5), V_O (Pin 6-5)
6N138 . . . . . −0.5 to 7V
6N139 . . . . . −0.5 to 18V
Output Power Dissipation . . . . . 100mW [4]

See notes, following page.

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

*JEDEC Registered Data. **JEDEC Registered 0°C to 70°C

Electrical Specifications

OVER RECOMMENDED TEMPERATURE (T_A = 0°C to 70°C), UNLESS OTHERWISE SPECIFIED

Parameter	Sym.	Device	Min.	Typ.**	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR*	6N139	400 500	2000 1600		%	I_F = 0.5mA, V_O = 0.4V, V_{CC} = 4.5V I_F = 1.6mA, V_O = 0.4V, V_{CC} = 4.5V	3	5,6
		6N138	300	1600		%	I_F = 1.6mA, V_O = 0.4V, V_{CC} = 4.5V		
Logic Low Output Voltage	V_{OL}	6N139		0.1 0.1 0.2	0.4 0.4 0.4	V	I_F = 1.6mA, I_O = 8mA, V_{CC} = 4.5V I_F = 5mA, I_O = 15mA, V_{CC} = 4.5V I_F = 12mA, I_O = 24mA, V_{CC} = 4.5V	1,2	6
		6N138		0.1	0.4	V	I_F = 1.6mA, I_O = 4.8mA, V_{CC} = 4.5V		
Logic High Output Current	I_{OH}*	6N139		0.05	100	μA	I_F = 0mA, V_O = V_{CC} = 18V		6
		6N138		0.1	250	μA	I_F = 0mA, V_O = V_{CC} = 7V		
Logic Low Supply Current	I_{CCL}			0.4		mA	I_F = 1.6mA, V_O = Open, V_{CC} = 5V		6
Logic High Supply Current	I_{CCH}			10		nA	I_F = 0mA, V_O = Open, V_{CC} = 5V		6
Input Forward Voltage	V_F*			1.4	1.7	V	I_F = 1.6mA, T_A = 25°C	4	
Input Reverse Breakdown Voltage	BV_R*		5		V		I_R = 10μA, T_A=25°C		
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$			−1.8		mV/°C	I_F = 1.6mA		
Input Capacitance	C_{IN}			60		pF	f=1MHz, V_F = 0		
Input-Output Insulation	I_{I-O}*				1	μA	45% RH, t = 5s, V_{I-O} = 3kV dc, T_A = 25°C		7,11
OPT. 010	V_{ISO}	2500				V_{RMS}	RH ≤ 50%, t = 1 min.		12
Resistance (Input-Output)	R_{I-O}			10^{12}		Ω	V_{I-O} = 500Vdc		7
Capacitance (Input-Output)	C_{I-O}			0.6		pF	f = 1MHz		7

*JEDEC registered data.

**All typicals at T_A = 25°C and V_{CC} = 5V, unless otherwise noted.

Switching Specifications

AT T_A = 25° C, V_{CC} = 5V

Parameter	Sym.	Device	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time To Logic Low at Output	t_{PHL}*	6N139		5 0.2	25 1	μs	I_F = 0.5mA, R_L = 4.7kΩ I_F = 12mA, R_L = 270Ω	7	6,8
		6N138		1.6	10	μs	I_F = 1.6mA, R_L = 2.2kΩ		
Propagation Delay Time To Logic High at Output	t_{PLH}*	6N139		18 2	60 7	μs	I_F = 0.5mA, R_L = 4.7kΩ I_F = 12mA, R_L = 270Ω	7	6,8
		6N138		10	35	μs	I_F = 1.6mA, R_L = 2.2kΩ		
Common Mode Transient Immunity at Logic High Level Output	$\lvert CM_H \rvert$			500		V/μs	I_F = 0mA, R_L = 2.2kΩ, R_{CC} = 0 $\lvert V_{cm} \rvert$ = 10V_{p-p}	8	9,10
Common Mode Transient Immunity at Logic Low Level Output	$\lvert CM_L \rvert$			500		V/μs	I_F = 1.6mA, R_L = 2.2kΩ, R_{CC} = 0 $\lvert V_{cm} \rvert$ = 10V_{p-p}	8	9,10

NOTES:

1. Derate linearly above 50° C free-air temperature at a rate of 0.4mA/° C.
2. Derate linearly above 50° C free-air temperature at a rate of 0.7mW/° C.
3. Derate linearly above 25° C free-air temperature at a rate of 0.7mA/° C.
4. Derate linearly above 25° C free-air temperature at a rate of 2.0mW/° C.
5. DC CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
6. Pin 7 Open.
7. Device considered a two-terminal device: Pins 1, 2, 3, and 4 shorted together and Pins 5, 6, 7, and 8 shorted together.
8. Use of a resistor between pin 5 and 7 will decrease gain and delay time. See Application Note 951-1 for more details.
9. Common mode transient immunity in Logic High level is the maximum tolerable (positive) dV_{cm}/dt on the leading edge of the common mode pulse, V_{cm}, to assure that the output will remain in a Logic High state (i.e., $V_O > 2.0V$). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) dV_{cm}/dt on the trailing edge of the common mode pulse signal, V_{cm}, to assure that the output will remain in a Logic Low state (i.e., $V_O < 0.8V$).
10. In applications where dV/dt may exceed 50,000V/μs (such as static discharge) a series resistor, R_{CC}, should be included to protect the detector IC from destructively high surge currents. The recommended value is $R_{CC} \approx \frac{1V}{0.15\ I_F\ (mA)}$ kΩ.
11. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
12. See Option 010 data sheet for more information.

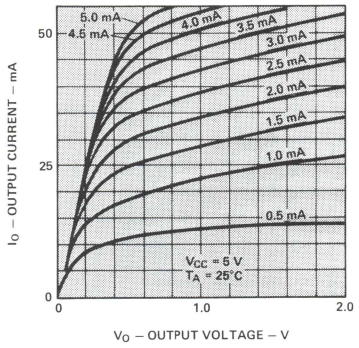


Figure 1. 6N138/6N139 DC Transfer Characteristics

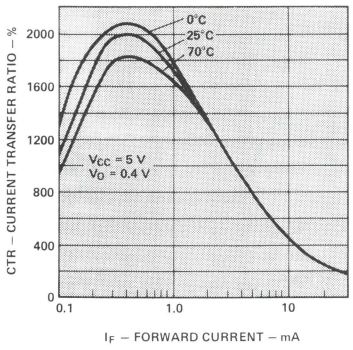


Figure 2. Current Transfer Ratio vs Forward Current 6N138/6N139

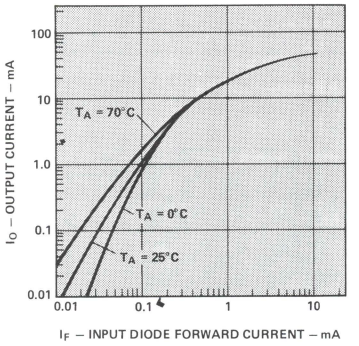


Figure 3. 6N138/6N139 Output Current vs Input Diode Forward Current

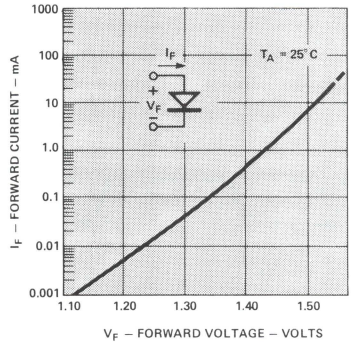


Figure 4. Input Diode Forward Current vs. Forward Voltage.

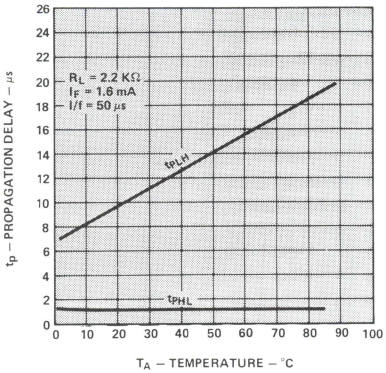


Figure 5. Propagation Delay vs. Temperature.

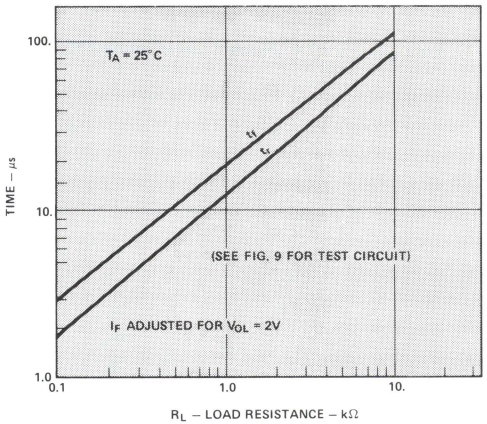


Figure 6. Non Saturated Rise and Fall Times vs. Load Resistance.

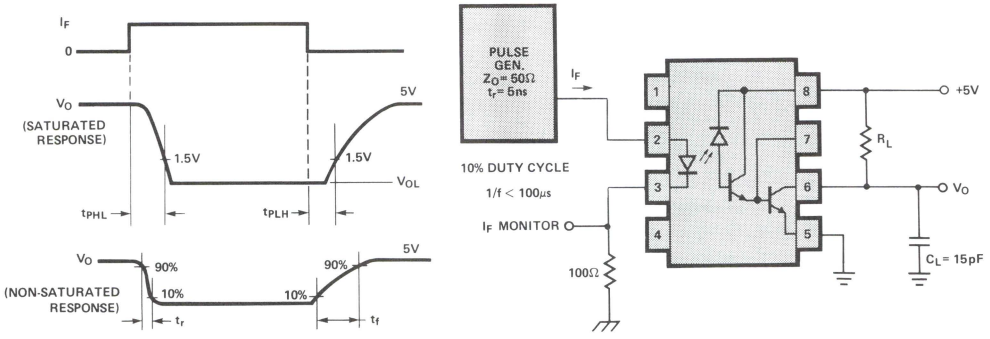


Figure 7. Switching Test Circuit.*

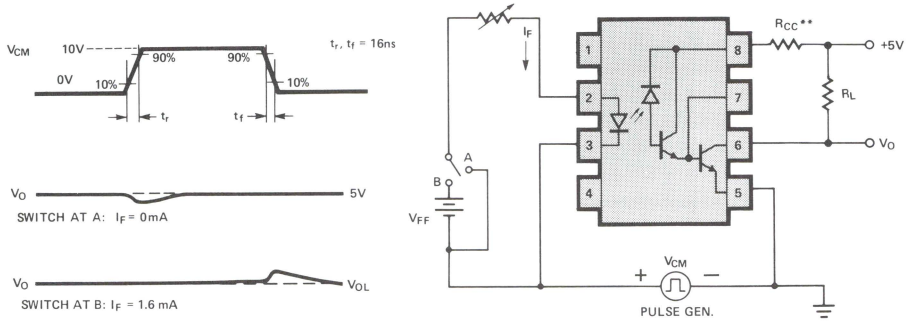


Figure 8. Test Circuit for Transient Immunity and Typical Waveforms.

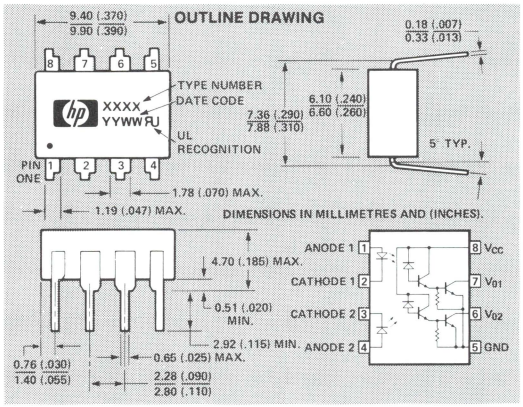
*JEDEC Registered Data.

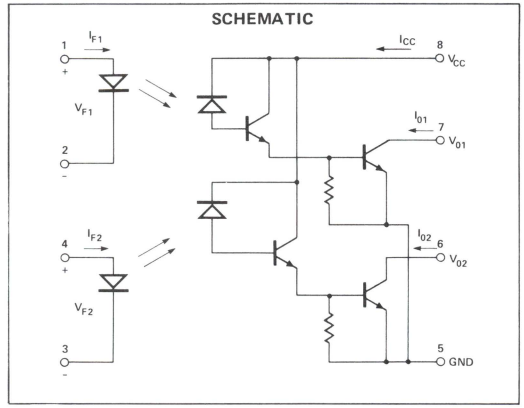
**See Note 10

HEWLETT PACKARD

DUAL LOW INPUT CURRENT, HIGH GAIN OPTOCOUPLERS

HCPL-2730
HCPL-2731





Features

- **HIGH CURRENT TRANSFER RATIO — 1800% TYPICAL**
- **LOW INPUT CURRENT REQUIREMENT — 0.5 mA**
- **LOW OUTPUT SATURATION VOLTAGE — 0.1V TYPICAL**
- **HIGH DENSITY PACKAGING**
- **PERFORMANCE GUARANTEED OVER 0°C TO 70°C TEMPERATURE RANGE**
- **HIGH COMMON MODE REJECTION — 500 V/μS**
- **LSTTL COMPATIBLE**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**
- **HCPL-5730/1 COMPATIBILITY**

Applications

- **Digital Logic Ground Isolation**
- **Telephone Ring Detector**
- **EIA RS-232C Line Receiver**
- **Low Input Current Line Receiver — Long Line or Party Line**
- **Microprocessor Bus Isolation**
- **Current Loop Receiver**
- **Polarity Sensing**
- **Level Shifting**
- **Line Voltage Status Indicator — Low input Power Dissipation**

Description

The HCPL-2730/31 dual channel couplers contain a separated pair of GaAsP light emitting diodes optically coupled to a pair of integrated high gain photon detectors. They provide extremely high current transfer ratio, 3000V dc withstand test voltage and excellent input-output common mode transient immunity. A separate pin for the photodiodes and first gain stages (V_{CC}) permits lower output saturation voltage and higher speed operation than possible with conventional photodarlington type isolators. In addition V_{CC} may be as low as 1.6V without adversely affecting the parametric performance.

Guaranted operation at low input currents and the high current transfer ratio (CTR) reduce the magnitude and effects of CTR degradation.

The outstanding high temperature performance of this split Darlington type output amplifier results from the inclusion of an integrated emitter-base bypass resistor which shunts photodiode and first stage leakage currents to ground.

The HCPL-2731 has a 400% minimum CTR at an input current of only 0.5 mA making it ideal for use in low input current application such as MOS, CMOS and low power logic interfacing or RS232C data transmission systems. In addition, the high CTR and high output current capability make this device extremely useful in applications where a high fanout is required. Compatibility with high voltage CMOS logic systems is guaranteed by the 18V V_{CC} and V_O specifications and by testing output high leakage (I_{OH}) at 18V.

The HCPL-2730 is specified at an input current of 16 mA and has a 7V V_{CC} and V_O rating. The 300% mimimum CTR allows TTL to TTL interfacing with an input current of only 1.6 mA.

Important specifications such as CTR, leakage current and output saturation voltage are guaranteed over the 0°C to 70°C temperature range to allow trouble-free system operation.

Electrical Specifications

(Over Recommended Temperature T_A = 0°C to 70°C, Unless Otherwise Specified)

Parameter	Sym.	Device HCPL-	Min.	Typ.*	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR	2731	400 500	1800 1600		%	I_F = 0.5mA, V_O = 0.4V, V_{CC} = 4.5V I_F = 1.6mA, V_O = 0.4V, V_{CC} = 4.5V	2	6,7
		2730	300	1600		%	I_F = 1.6mA, V_O = 0.4V, V_{CC} = 4.5V	2	
Logic Low Output Voltage	V_{OL}	2731		0.1 0.1 0.2	0.4 0.4 0.4	V	I_F = 1.6mA, I_O = 8mA, V_{CC} = 4.5V I_F = 5mA, I_O = 15mA, V_{CC} = 4.5V I_F = 12mA, I_O = 24mA, V_{CC} = 4.5V	1	6
		2730		0.1	0.4	V	I_F = 1.6mA, I_O = 4.8mA, V_{CC} = 4.5V		
Logic High Output Current	I_{OH}	2731		0.005	100	μA	I_F = 0 mA, V_O = V_{CC} = 18V		6
		2730		0.01	250	μA	I_F = 0mA, V_O = V_{CC} = 7V		
Logic Low Supply Current	I_{CCL}	2731		1.2		mA	I_{F1} = I_{F2} = 1.6mA, V_{CC} = 18V		
		2730		0.9			V_{01} = V_{02} = Open, V_{CC} = 7V		
Logic High Supply Current	I_{CCH}	2731		5		nA	I_{F1} = I_{F2} = 0mA, V_{CC} = 18V		
		2730		4			V_{01} = V_{02} = Open, V_{CC} = 7V		
Input Forward Voltage	V_F			1.4	1.7	V	I_F = 1.6mA, T_A = 25°C	4	6
Input Reverse Breakdown Voltage	BV_R		5			V	I_R = 10 μA, T_A = 25°C		6
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$			-1.8		mV/°C	I_F = 1.6mA		6
Input Capacitance	C_{IN}			60		pF	f = 1 MHz, V_F = 0		6
Input-Output Insulation	I_{I-O}				1	μA	45% RH, t = 5s, V_{I-O} = 3kV dc, T_A = 25°C		8,12
OPT. 010	V_{ISO}		2500			V_{RMS}	RH ≤ 50%, t = 1 min.		13
Resistance (Input-Output)	R_{I-O}			10^{12}		Ω	V_{I-O} = 500Vdc		8
Capacitance (Input-Output)	C_{I-O}			0.6		pF	f = 1 MHz		8
Input-Input Insulation Leakage Current	I_{I-I}			0.005		μA	45% Relative Humidity, t=5s, V_{I-I} = 500Vdc		9
Resistance (Input-Input)	R_{I-I}			10^{11}		Ω	V_{I-I} = 500Vdc		9
Capacitance (Input-Input)	C_{I-I}			0.25		pF	f = 1 MHz		9

*All typicals at T_A = 25°C

Switching Specifications At T_A = 25°C, V_{CC} = 5V

Parameter	Sym.	Device HCPL-	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time To Logic Low at Output	t_{PHL}	2731		25	100	μs	I_F = 0.5mA, R_L = 4.7kΩ	9	6
		2730/1		5 0.5	20 2	μs	I_F = 1.6mA, R_L = 2.2kΩ I_F = 12mA, R_L = 270Ω		
Propagation Delay Time To Logic High at Output	t_{PLH}	2731		10	60	μs	I_F = 0.5mA, R_L = 4.7kΩ	9	6
		2730/1		10 1	35 10	μs	I_F = 1.6mA, R_L = 2.2kΩ I_F = 12mA, R_L = 270Ω		
Common Mode Transient Immunity at Logic High Level Output	$\lvert CM_H \rvert$			500		V/μs	I_F = 0mA, R_L = 2.2kΩ $\lvert V_{CM} \rvert$ = 10V_{p-p}	10	6, 10, 11
Common Mode Transient Immunity at Logic Low Level Output	$\lvert CM_L \rvert$			500		V/μs	I_F = 1.6mA, R_L = 2.2kΩ $\lvert V_{CM} \rvert$ = 10V_{p-p}	10	6, 10, 11

NOTES:
1. Derate linearly above 50°C free-air temperature at a rate of 0.5mA/°C.
2. Derate linearly above 50°C free-air temperature at a rate of 0.9mW/°C.
3. Derate linearly above 35°C free-air temperature at a rate of 0.6mA/°C.
4. Pin 5 should be the most negative voltage at the detector side.
5. Derate linearly above 35°C free-air temperature at a rate of 1.7mW/°C. Output power is collector output power plus supply power.
6. Each channel.
7. CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
8. Device considered a two-terminal device: Pins 1, 2, 3, and 4 shorted together and Pins 5, 6, 7, and 8 shorted together.
9. Measured between pins 1 and 2 shorted together, and pins 3 and 4 shorted together.
10. Common mode transient immunity in Logic High level is the maximum tolerable (positive) dV_{CM}/dt on the leading edge of the common mode pulse V_{CM}, to assure that the output will remain in Logic High state (i.e., V_O > 2.0V). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) dV_{CM} dt on the trailing edge of the common mode pulse signal, V_{CM}, to assure that the output will remain in a Logic Low state (i.e., V_O < 0.8V).
11. In applications where dV/dt may exceed 50,000 V/μs (such as a static discharge) a series resistor, R_{CC}, should be included to protect the detector IC from destructively high surge currents. The recommended value is $R_{CC} \simeq \frac{1V}{0.3\ I_F\ (mA)}$ kΩ.
12. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
13. See Option 010 data sheet for more information.

Absolute Maximum Ratings

Storage Temperature ..... -55°C to +125°C
Operating Temperature ..... -40°C to +85°C
Lead Solder Temperature ..... 260°C for 10 sec
(1.6mm below seating plane)
Average Input Current — I_F
(each channel) ..... 20 mA[1]
Peak Input Current — I_F
(each channel) ..... 40 mA
(50% duty cycle, 1 ms pulse width)
Reverse Input Voltage — V_R
(each channel) 5V
Input Power Dissipation
(each channel) ..... 35 mW[2]
Output Current — I_O
(each channel) ..... 60 mA[3]
Supply and Output Voltage — V_{CC} (Pin 8-5), V_O (Pin 7,6-5)[4]
HCPL-2730 ..... -0.5 to 7V
HCPL-2731 ..... -0.5 to 18V
Output Power Dissipation
(each channel) ..... 100 mW[5]

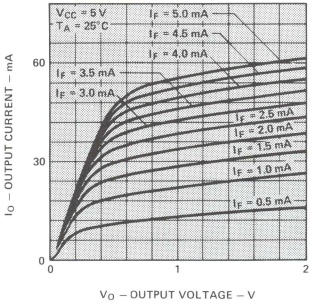


Figure 1. DC Transfer Characteristics (HCPL-2730/HCPL-2731)

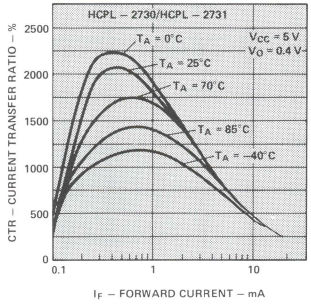


Figure 2. Current Transfer Ratio vs Forward Current

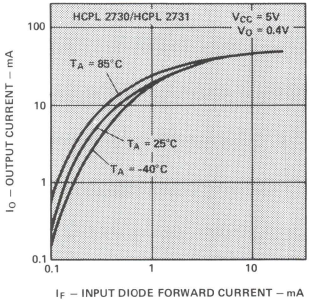


Figure 3. Output Current vs Input Diode Forward Current

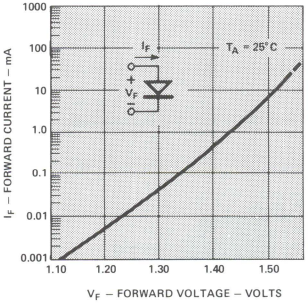


Figure 4. Input Diode Forward Current vs. Forward Voltage.

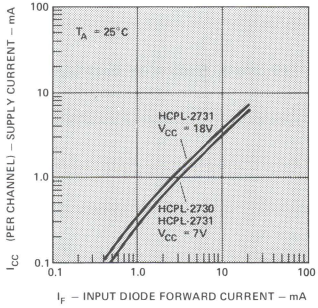


Figure 5. Supply Current Per Channel vs. Input Diode Forward Current.

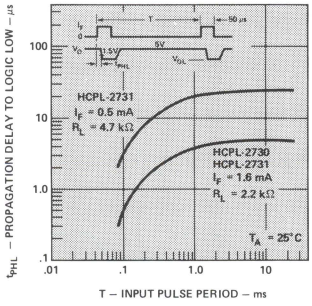


Figure 6. Propagation Delay To Logic Low vs. Pulse Period.

OPTOCOUPLERS

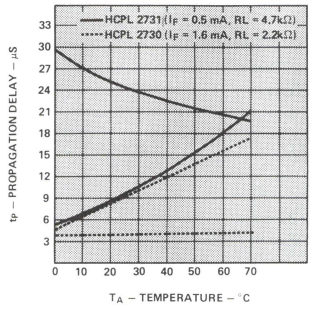


Figure 7. Propagation Delay vs. Temperature.

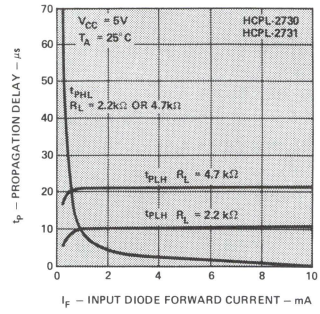


Figure 8. Propagation Delay vs. Input Diode Forward Current.

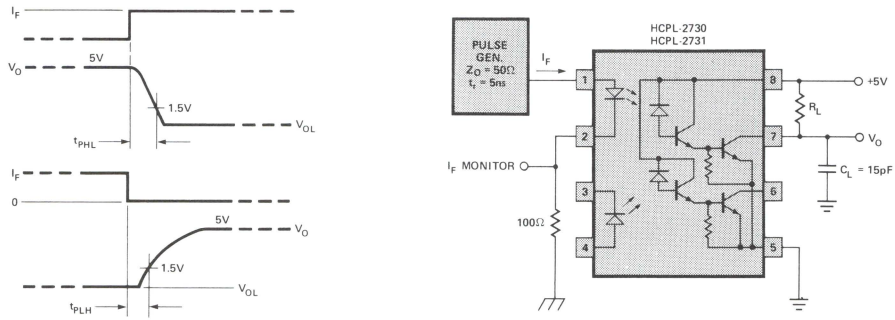


Figure 9. Switching Test Circuit.

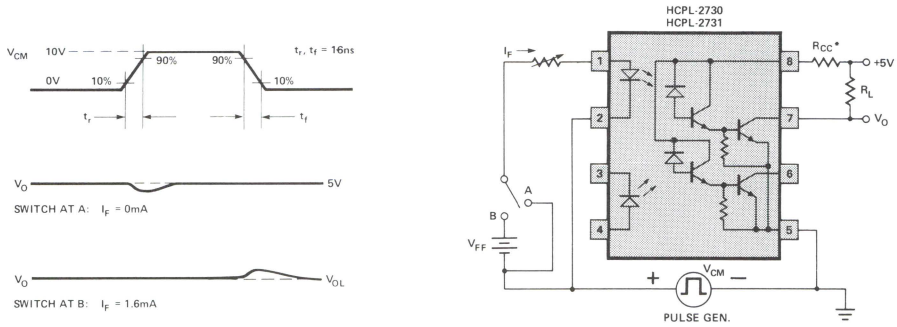
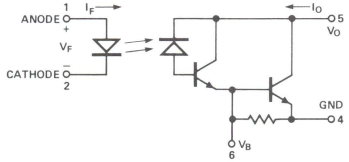


Figure 10. Test Circuit for Transient Immunity and Typical Waveforms.

HEWLETT PACKARD

LOW INPUT CURRENT, HIGH GAIN OPTOCOUPLER

4N45
4N46



Features

- **HIGH CURRENT TRANSFER RATIO — 1500% TYPICAL**
- **LOW INPUT CURRENT REQUIREMENT — 0.5 mA**
- **PERFORMANCE GUARANTEED OVER 0°C TO 70°C TEMPERATURE RANGE**
- **INTERNAL BASE-EMITTER RESISTOR MINIMIZES OUTPUT LEAKAGE**
- **GAIN-BANDWIDTH ADJUSTMENT PIN**
- **HIGH COMMON MODE REJECTION**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**

Description

The 4N45/46 optocouplers contain a GaAsP light emitting diode optically coupled to a high gain photodetector IC.

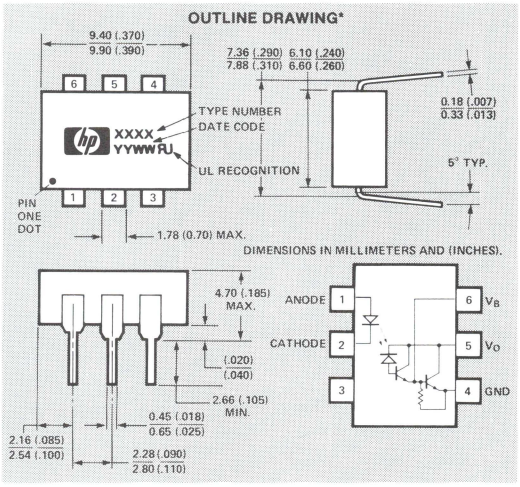
The excellent performance over temperature results from the inclusion of an integrated emitter-base bypass resistor which shunts photodiode and first stage leakage currents to ground. External access to the second stage base provides better noise rejection than a conventional photodarlington detector. An external resistor or capacitor at the base can be added to make a gain-bandwidth or input current threshold adjustment. The base lead can also be used for feedback.

The high current transfer ratio at very low input currents permits circuit designs in which adequate margin can be allowed for the effects of CTR degradation over time.

The 4N46 has a 350% minimum CTR at an input current of only 0.5mA making it ideal for use in low input current applications such as MOS, CMOS and low power logic interfacing. Compatibility with high voltage CMOS logic systems is assured by the 20V minimum breakdown voltage of the output transistor and by the guaranteed maximum output leakage (I_{OH}) at 18V.

The 4N45 has a 250% minimum CTR at 1.0mA input current and a 7V minimum breakdown voltage rating.

*JEDEC Registered Data. **JEDEC Registered up to 70°C



Applications

- **Telephone Ring Detector**
- **Digital Logic Ground Isolation**
- **Low Input Current Line Receiver**
- **Line Voltage Status Indicator — Low Input Power Dissipation**
- **Logic to Reed Relay Interface**
- **Level Shifting**
- **Interface Between Logic Families**

Absolute Maximum Ratings*

Storage Temperature ..... -55°C to +125°C
Operating Temperature** ..... -40°C to +85°C
Lead Solder Temperature ..... 260°C for 10 s.
(1.6mm below seating plane)
Average Input Current — I_F ..... 20 mA[1]
Peak Input Current — I_F ..... 40 mA
(50% duty cycle, 1ms pulse width)
Peak Transient Input Current — I_F 1.0A
($\leqslant$1 µs pulse width, 300pps)
Reverse Input Voltage — V_R 5V
Input Power Dissipation ..... 35mW[2]
Output Current — I_O (Pin 5) ..... 60 mA[3]
Emitter-Base Reverse Voltage (Pins 4-6) 0.5V
Output Voltage — V_O (Pin 5-4)
4N45 ..... -0.5 to 7V
4N46 ..... -0.5 to 20V
Output Power Dissipation ..... 100mW[4]
See notes, following page

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

OPTOCOUPLERS

Electrical Specifications

OVER RECOMMENDED TEMPERATURE (T_A = 0°C TO 70°C), UNLESS OTHERWISE SPECIFIED

Parameter	Sym.	Device	Min.	Typ.**	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR*	4N46	350 500 200	1500 1500 600		%	I_F = 0.5mA, V_O = 1.0V I_F = 1.0mA, V_O = 1.0V I_F = 10mA, V_O = 1.2V	4	5,6
		4N45	250 200	1200 500		%	I_F = 1.0mA, V_O = 1.0V I_F = 10mA, V_O = 1.2V		
Logic Low Output Voltage	V_{OL}	4N46		.90 .92 .95	1.0 1.0 1.2	V	I_F = 0.5mA, I_{OL} = 1.75mA I_F = 1.0mA, I_{OL} = 5.0mA I_F = 10mA, I_{OL} = 20mA	2	6
		4N45		.90 .95	1.0 1.2	V	I_F = 1.0mA, I_{OL} = 2.5mA I_F = 10mA, I_{OL} = 20mA		
Logic High Output Current	I_{OH}*	4N46		.001	100	μA	I_F = 0mA, V_O = 18V		6
		4N45		.001	250	μA	I_F = 0mA, V_O = 5V		
Input Forward Voltage	V_F*			1.4	1.7	V	I_F = 1.0mA, T_A = 25°C	1	
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$			-1.8		mV/°C	I_F = 1.0mA		
Input Reverse Breakdown Voltage	BV_R*		5			V	I_R = 10μA, T_A = 25°C		
Input Capacitance	C_{IN}			60		pF	f = 1MHz, V_F = 0		
Input-Output Insulation	I_{I-O}*				1.0	μA	45% RH, t = 5s, V_{I-O} = 3kV dc, T_A = 25°C		7,10
OPT. 010	V_{ISO}		2500			V_{RMS}	RH ≤ 50%, t = 1 min.		11
Resistance (Input-Output)	R_{I-O}			10^{12}		Ω	V_{I-O} = 500VDC		7
Capacitance (Input-Output)	C_{I-O}			0.6		pF	f = 1MHz		7

Switching Specifications

AT T_A = 25° C, V_{CC} = 5.0V

Parameter	Symbol	Min.	Typ.**	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time To Logic Low at Output	t_{PHL}		80		μs	I_F = 1.0mA, R_L = 10kΩ	8	6,8
	t_{PHL}*		5	50	μs	I_F = 10mA, R_L = 220Ω		
Propagation Delay Time To Logic High at Output	t_{PLH}		1500		μs	I_F = 1.0mA, R_L = 10kΩ	8	6,8
	t_{PLH}*		150	500	μs	I_F = 10mA, R_L = 220Ω		
Common Mode Transient Immunity at Logic High Level Output	$\|CM_H\|$		500		V/μs	I_F = 0mA, R_L = 10kΩ $\|V_{cm}\|$ = $10V_{p-p}$	9	9
Common Mode Transient Immunity at Logic Low Level Output	$\|CM_L\|$		500		V/μs	I_F = 1.0mA, R_L = 10kΩ $\|V_{cm}\|$ = $10V_{p-p}$	9	9

*JEDEC Registered Data.

**All typicals at T_A = 25°C, unless otherwise noted.

NOTES:

1. Derate linearly above 50° C free-air temperature at a rate of 0.4mA/° C.
2. Derate linearly above 50° C free-air temperature at a rate of 0.7mW/° C.
3. Derate linearly above 25° C free-air temperature at a rate of 0.8mA/° C.
4. Derate linearly above 25° C free-air temperature at a rate of 1.5mW/° C.
5. DC CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
6. Pin 6 Open.
7. Device considered a two-terminal device: Pins 1, 2, 3 shorted together and Pins 4, 5, and 6 shorted together.
8. Use of a resistor between pin 4 and 6 will decrease gain and delay time. (See Figures 10 and 12).
9. Common mode transient immunity in Logic High level is the maximum tolerable (positive) dV_{cm}/dt on the leading edge of the common mode pulse, V_{cm}, to assure that the output will remain in a Logic High state (i.e., $V_O > 2.5V$). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) dV_{cm}/dt on the trailing edge of the common mode pulse signal, V_{cm}, to assure that the output will remain in a Logic Low state (i.e., $V_O < 2.5V$).
10. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
11. See Option 010 data sheet for more information.

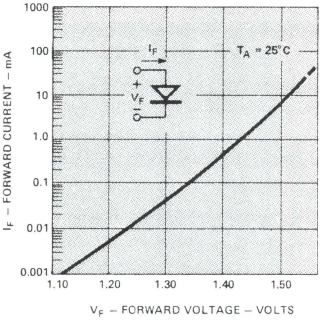


Figure 1. Input Diode Forward Current vs. Forward Voltage.

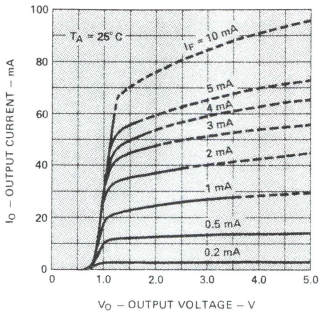


Figure 2. Typical DC Transfer Characteristics.

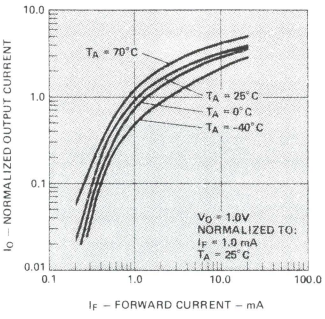


Figure 3. Output Current vs. Input Current.

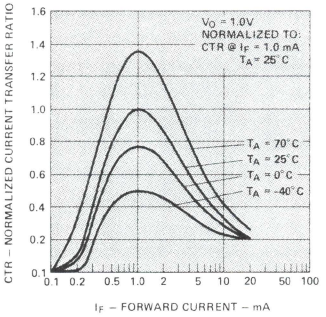


Figure 4. Current Transfer Ratio vs. Input Current.

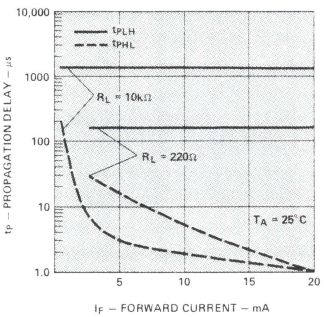


Figure 5. Propagation Delay vs. Forward Current.

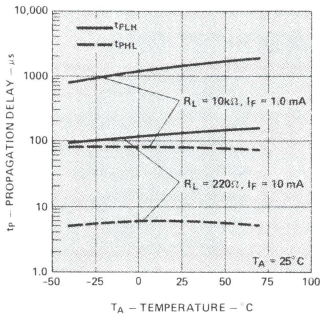


Figure 6. Propagation Delay vs. Temperature.

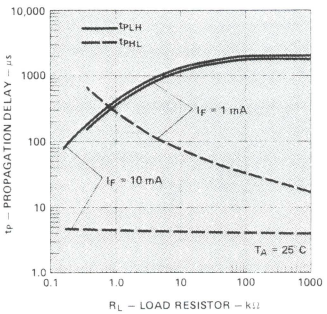
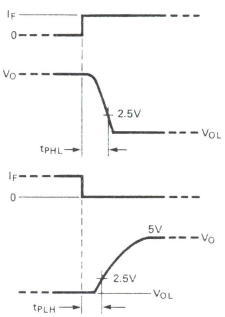


Figure 7. Propagation Delay vs Load Resistor.



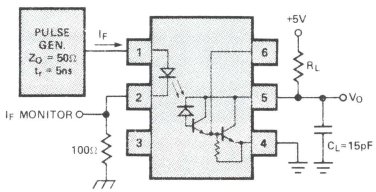
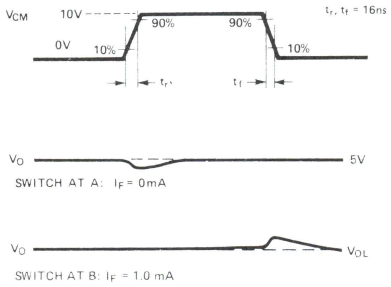


Figure 8. Switching Test Circuit



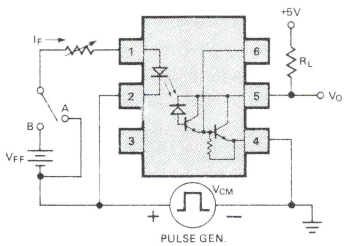


Figure 9. Test Circuit for Transient Immunity and Typical Waveforms.

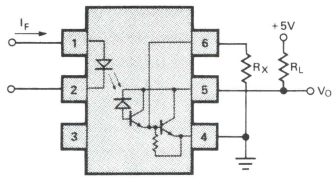


Figure 10. External Base Resistor, R_X

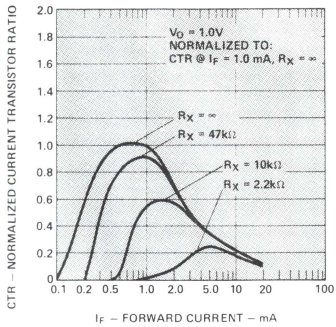


Figure 11. Effect of R_X On Current Transfer Ratio

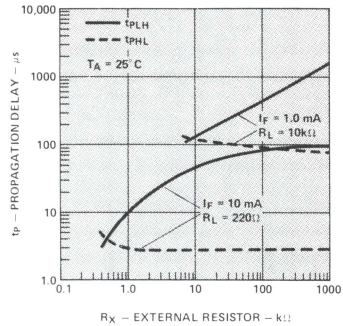
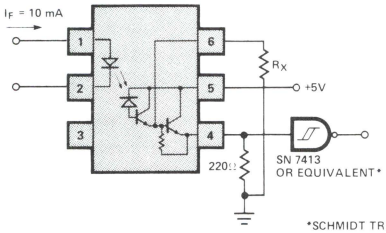


Figure 12. Effect of R_X On Propagation Delay

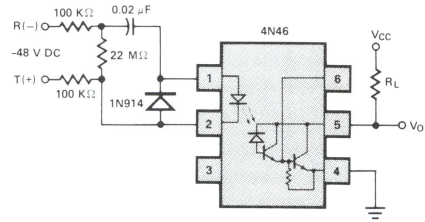
Applications



R_X (kΩ)	t_{PHL} (μs)	t_{PLH} (μs)
∞	5	320
100	5	200
47	5	140
20	6	80
10	6	45

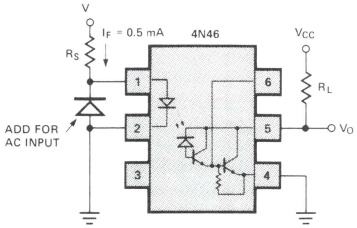
*SCHMIDT TRIGGER RECOMMENDED BECAUSE OF LONG t_r, t_f.

TTL Interface



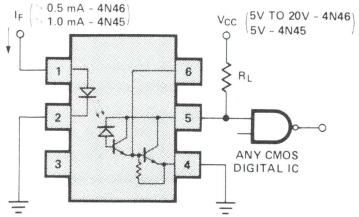
NOTE: AN INTEGRATOR MAY BE REQUIRED AT THE OUTPUT TO ELIMINATE DIALING PULSES AND LINE TRANSIENTS.

Telephone Ring Detector

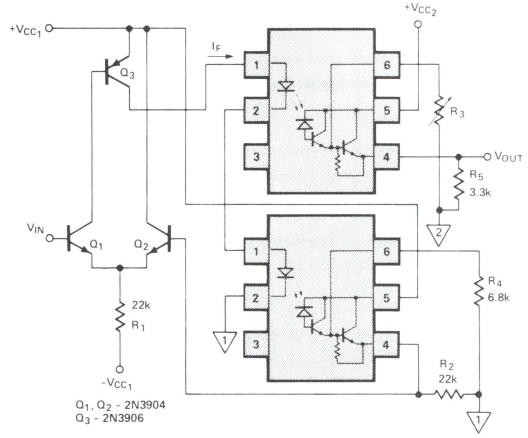


V (Vdc or Vrms)	R_S	V • I_F (mW)
24	47kΩ	11
48	100kΩ	22
115	220kΩ	62
230	470kΩ	113

Line Voltage Monitor



CMOS Interface



Analog Signal Isolation

CHARACTERISTICS

R_{IN} ≈ 30MΩ, R_{OUT} ≈ 50Ω

$V_{IN\,(MAX.)} = V_{CC_1}$ - 1V, LINEARITY BETTER THAN 5%

DESIGN COMMENTS

R_1 - NOT CRITICAL $\left(\leq \frac{V_{IN\,(MAX.)} - (-V_{CC_1}) - V_{BE}}{I_{F\,(MAX.)}}\right) h_{FE}\ Q_3$

R_2 - NOT CRITICAL (OMIT IF 0.2 TO 0.3V OFFSET IS TOLERABLE)

$R_4 = \frac{V_{IN\,(MAX.)} + V_{BE}}{1\ mA}$

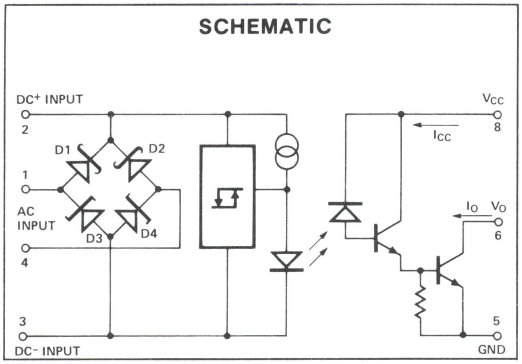
$R_5 = \frac{V_{IN\,(MAX.)}}{2.5\ mA}$

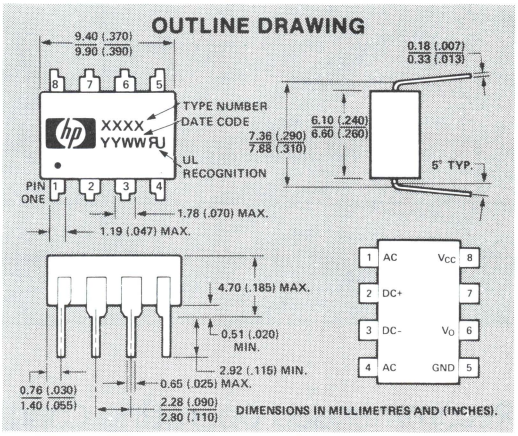
NOTE: ADJUST R_3 SO $V_{OUT} = V_{IN}$ AT $V_{IN} = \frac{V_{IN\,(MAX.)}}{2}$

HEWLETT PACKARD

AC/DC TO LOGIC INTERFACE OPTOCOUPLER

HCPL-3700



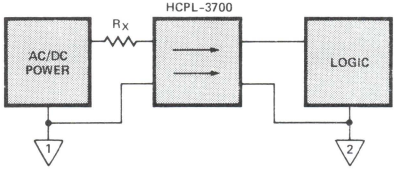


Features

- AC OR DC INPUT
- PROGRAMMABLE SENSE VOLTAGE
- HYSTERESIS
- LOGIC COMPATIBLE OUTPUT
- SMALL SIZE: STANDARD 8 PIN DIP
- THRESHOLDS GUARANTEED OVER TEMPERATURE
- THRESHOLDS INDEPENDENT OF LED CHARACTERISTICS
- RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).
- HCPL-5760 COMPATIBILITY

Applications

- LIMIT SWITCH SENSING
- LOW VOLTAGE DETECTOR
- AC/DC VOLTAGE SENSING
- RELAY CONTACT MONITOR
- RELAY COIL VOLTAGE MONITOR
- CURRENT SENSING
- MICROPROCESSOR INTERFACING
- TELEPHONE RING DETECTION



Description

The HCPL-3700 is a voltage/current threshold detection optocoupler. This optocoupler uses an internal Light Emitting Diode (LED), a threshold sensing input buffer IC, and a high gain photon detector to provide an optocoupler which permits adjustable external threshold levels. The input buffer circuit has a nominal turn on threshold of 2.5 mA (I_{TH+}) and 3.8 volts (V_{TH+}). The addition of one or more external attenuation resistors permits the use of this device over a wide range of input voltages and currents. Threshold sensing prior to the LED and detector elements minimizes effects of different optical gain and LED variations over operating life (CTR degradation). Hysteresis is also provided in the buffer for extra noise immunity and switching stability.

The buffer circuit is designed with internal clamping diodes to protect the circuitry and LED from a wide range of over-voltage and over-current transients while the diode bridge enables easy use with ac voltage input.

The high gain output stage features an open collector output providing both TTL compatible saturation voltages and CMOS compatible breakdown voltages.

The HCPL-3700, by combining several unique functions in a single package, provides the user with an ideal component for industrial control computer input boards and other applications where a predetermined input threshold optocoupler level is desirable.

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

Absolute Maximum Ratings (No derating required up to 70° C)

Parameter		Symbol	Min.	Max.	Units	Note
Storage Temperature		T_S	-55	125	°C	
Operating Temperature		T_A	-40	85	°C	
Lead Soldering Cycle	Temperature			260	°C	1
	Time			10	sec	
Input Current	Average	I_{IN}		50	mA	2
	Surge			140		2,3
	Transient			500		
Input Voltage (Pins 2-3)		V_{IN}	-0.5		V	
Input Power Dissipation		P_{IN}		230	mW	4
Total Package Power Dissipation		P		305	mW	5
Output Power Dissipation		P_O		210	mW	6
Output Current	Average	I_O		30	mA	7
Supply Voltage (Pins 8-5)		V_{CC}	-0.5	20	V	
Output Voltage (Pins 6-5)		V_O	-0.5	20	V	

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units	Note
Supply Voltage	V_{CC}	2	18	V	
Operating Temperature	T_A	0	70	°C	
Operating Frequency	f	0	4	KHz	8

Switching Characteristics at $T_A = 25°C$, $V_{CC} = 5.0V$

Parameter	Symbol	Min.	Typ.[9]	Max.	Units	Conditions	Fig.	Note
Propagation Delay Time to Logic Low Output Level	t_{PHL}		4.0	15	μs	$R_L = 4.7\ k\Omega$, $C_L = 30\ pF$	6,9	10
Propagation Delay Time to Logic High Output Level	t_{PLH}		10.0	40	μs	$R_L = 4.7\ k\Omega$, $C_L = 30\ pF$		11
Common Mode Transient Immunity at Logic Low Output Level	$\lvert CM_L \rvert$		600		V/μs	$I_{IN} = 3.11\ mA$, $R_L = 4.7\ k\Omega$ $V_{O\ max.} = 0.8V$, $V_{CM_L} = 140V$	8,10	12,13
Common Mode Transient Immunity at Logic High Output Level	$\lvert CM_H \rvert$		4000		V/μs	$I_{IN} = 0\ mA$, $R_L = 4.7\ k\Omega$ $V_{O\ min.} = 2.0V$, $V_{CM_H} = 1400V$		
Output Rise Time (10-90%)	t_r		20		μs	$R_L = 4.7\ k\Omega$, $C_L = 30\ pF$	7	
Output Fall Time (90-10%)	t_f		0.3		μs	$R_L = 4.7\ k\Omega$, $C_L = 30\ pF$		

Electrical Characteristics

Over Recommended Temperature ($0°C \le T_A \le 70°C$) Unless Otherwise Specified

Parameter		Symbol	Min.	Typ.[9]	Max.	Units	Conditions	Fig.	Note
Input Threshold Current		I_{TH+}	1.96	2.5	3.11	mA	$V_{IN}=V_{TH+}$; V_{CC} = 4.5V; V_O = 0.4V; $I_O \ge$ 4.2 mA	2,3	14
		I_{TH-}	1.00	1.3	1.62	mA	$V_{IN} = V_{TH-}$; V_{CC} = 4.5V; V_O = 2.4V; $I_{OH} \le 100\ \mu A$		
Input Threshold Voltage	DC (Pins 2, 3)	V_{TH+}	3.35	3.8	4.05	V	$V_{IN} = V_2 - V_3$; Pins 1 & 4 Open V_{CC} = 4.5V; V_O = 0.4V; $I_O \ge$ 4.2 mA		
		V_{TH-}	2.01	2.6	2.86	V	$V_{IN} = V_2 - V_3$; Pins 1 & 4 Open V_{CC} = 4.5V; V_O = 2.4V; $I_O \le 100\ \mu A$		
	AC (Pins 1, 4)	V_{TH+}	4.23	5.1	5.50	V	$V_{IN} = \lvert V_1 - V_4 \rvert$; Pins 2 & 3 Open V_{CC} = 4.5V; V_O = 0.4V; $I_O \ge$ 4.2 mA		14,15
		V_{TH-}	2.87	3.8	4.24	V	$V_{IN} = \lvert V_1 - V_4 \rvert$; Pins 2 & 3 Open V_{CC} = 4.5V; V_O = 2.4V; $I_O \le 100\ \mu A$		
Hysteresis		I_{HYS}		1.2		mA	$I_{HYS} = I_{TH+} - I_{TH-}$	2	
		V_{HYS}		1.2		V	$V_{HYS} = V_{TH+} - V_{TH-}$		
Input Clamp Voltage		V_{IHC1}	5.4	5.9	6.6	V	$V_{IHC1} = V_2 - V_3$; V_3 = GND; I_{IN} = 10 mA; Pin 1 & 4 Connected to Pin 3	1	
		V_{IHC2}	6.1	6.6	7.3	V	$V_{IHC2} = \lvert V_1 - V_4 \rvert$; $\lvert I_{IN} \rvert$ = 10 mA; Pins 2 & 3 Open		
		V_{IHC3}		12.0	13.4	V	$V_{IHC3} = V_2 - V_3$; V_3 = GND; I_{IN} = 15 mA; Pins 1 & 4 Open		
		V_{ILC}		-0.76		V	$V_{ILC} = V_2 - V_3$; V_3 = GND; I_{IN} = -10 mA		
Input Current		I_{IN}	3.0	3.7	4.4	mA	$V_{IN} = V_2 - V_3$ = 5.0V; Pins 1 & 4 Open	5	
Bridge Diode Forward Voltage		$V_{D1,2}$		0.59			I_{IN} = 3 mA (see schematic)		
		$V_{D3,4}$		0.74					
Logic Low Output Voltage		V_{OL}		0.1	0.4	V	V_{CC} = 4.5V; I_{OL} = 4.2 mA	5	14
Logic High Output Current		I_{OH}			100	μA	$V_{OH} = V_{CC}$ = 18V		
Logic Low Supply Current		I_{CCL}		1.2	4	mA	$V_2 - V_3$ = 5.0V; V_O = Open V_{CC} = 5.0V		
Logic High Supply Current		I_{CCH}		0.002	4	μA	V_{CC} = 18V; V_O = Open	4	14
Input-Output Insulation		I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 3 kV dc, T_A = 25°C		16, 17
	OPT 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50% t = 1 MIN		18
Input-Output Resistance		R_{I-O}		10^{12}		Ω	V_{I-O} = 500 Vdc		16
Input-Output Capacitance		C_{I-O}		0.6		pF	f = 1 MHz, V_{I-O} = 0 Vdc		
Input Capacitance		C_{IN}		50		pF	f=1 MHz; V_{IN}=0V, Pins 2 & 3, Pins 1 & 4 Open		

Notes:

1. Measured at a point 1.6 mm below seating plane.
2. Current into/out of any single lead.
3. Surge input current duration is 3 ms at 120 Hz pulse repetition rate. Transient input current duration is 10 μs at 120 Hz pulse repetition rate. Note that maximum input power, P_{IN}, must be observed.
4. Derate linearly above 70° C free-air temperature at a rate of 4.1 mW/° C. Maximum input power dissipation of 230 mW allows an input IC junction temperature of 125° C at an ambient temperature of T_A = 70° C with a typical thermal resistance from junction to ambient of θ_{JA_i} = 240° C/W. Excessive P_{IN} and T_J may result in IC chip degradation.
5. Derate linearly above 70° C free-air temperature at a rate of 5.4 mW/° C.
6. Derate linearly above 70° C free-air temperature at a rate of 3.9 mW/° C. Maximum output power dissipation of 210 mW allows an output IC junction temperature of 125° C at an ambient temperature of T_A = 70° C with a typical thermal resistance from junction to ambient of θ_{JA_O} = 265° C/W.
7. Derate linearly above 70° C free-air temperature at a rate of 0.6 mA/° C.
8. Maximum operating frequency is defined when output waveform (Pin 6) attains only 90% of V_{CC} with R_L = 4.7 kΩ, C_L = 30 pF using a 5 V square wave input signal.

9. All typical values are at $T_A = 25°C$, $V_{CC} = 5.0V$ unless otherwise stated.
10. The t_{PHL} propagation delay is measured from the 2.5V level of the leading edge of a 5.0V input pulse (1 μs rise time) to the 1.5V level on the leading edge of the output pulse (see Figure 9).
11. The t_{PLH} propagation delay is measured from the 2.5V level of the trailing edge of a 5.0V input pulse (1 μs fall time) to the 1.5V level on the trailing edge of the output pulse (see Figure 9).
12. Common mode transient immunity in Logic High level is the maximum tolerable (positive) $dV_{CM/dt}$ on the leading edge of the common mode pulse, V_{CM}, to ensure that the output will remain in a Logic High state (i.e., $V_O > 2.0V$). Common mode transient immunity in Logic Low level is the maximum tolerable (negative) $dV_{CM/dt}$ on the trailing edge of the common mode pulse signal, V_{CM}, to ensure that the output will remain in a Logic Low state (i.e., $V_O < 0.8V$). See Figure 10.
13. In applications where $dV_{CM/dt}$ may exceed 50,000 V/μs (such as static discharge), a series resistor, R_{CC}, should be included to protect the detector IC from destructively high surge currents. The recommended value for R_{CC} is 240Ω per volt of allowable drop in V_{CC} (between Pin 8 and V_{CC}) with a minimum value of 240Ω.
14. Logic low output level at Pin 6 occurs under the conditions of $V_{IN} \geq V_{TH+}$ as well as the range of $V_{IN} > V_{TH-}$ once V_{IN} has exceeded V_{TH+}. Logic high output level at Pin 6 occurs under the conditions of $V_{IN} \leq V_{TH-}$ as well as the range of $V_{IN} < V_{TH+}$ once V_{IN} has decreased below V_{TH-}.
15. AC voltage is instantaneous voltage.
16. Device considered a two terminal device: pins 1, 2, 3, 4 connected together, and Pins 5, 6, 7, 8 connected together.
17. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
18. See Option 010 data sheet for more information.

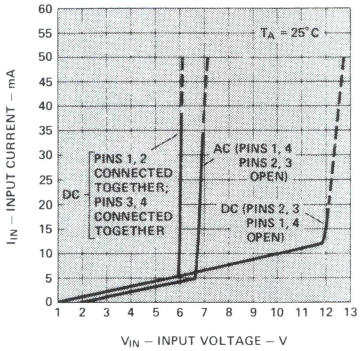


Figure 1. Typical Input Characteristics, I_{IN} vs. V_{IN}. (AC voltage is instantaneous value.)

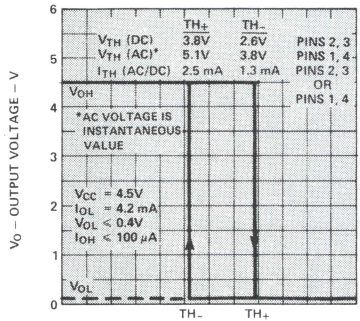


Figure 2. Typical Transfer Characteristics. (AC voltage is instantaneous value.)

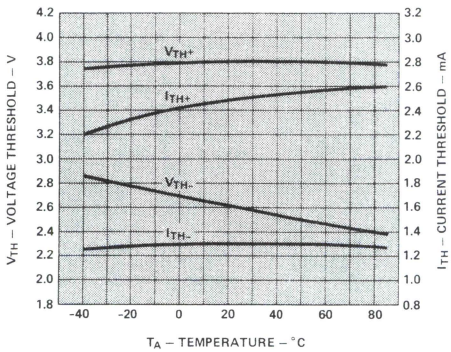


Figure 3. Typical DC Threshold Levels vs. Temperature.

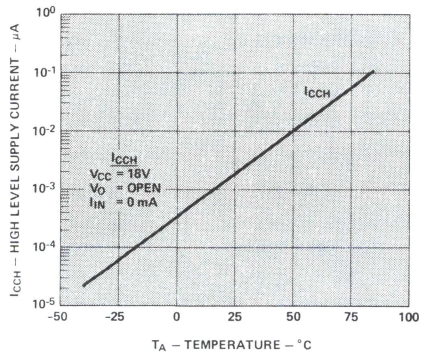


Figure 4. Typical High Level Supply Current, I_{CCH} vs. Temperature.

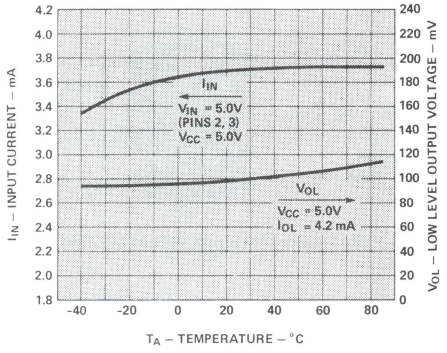


Figure 5. Typical Input Current, I_{IN}, and Low Level Output Voltage, V_{OL}, vs. Temperature.

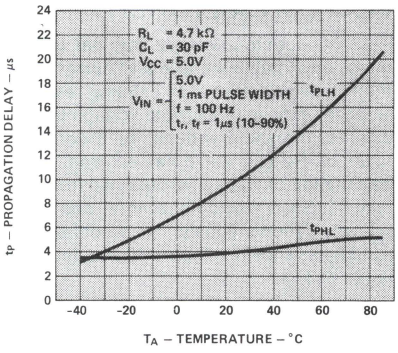


Figure 6. Typical Propagation Delay vs. Temperature.

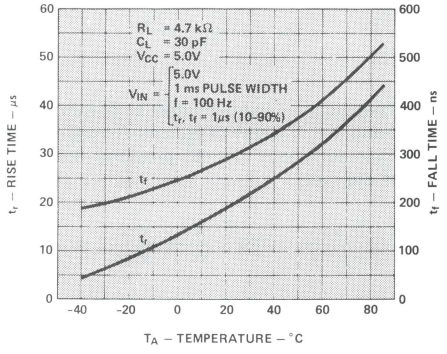


Figure 7. Typical Rise, Fall Times vs. Temperature.

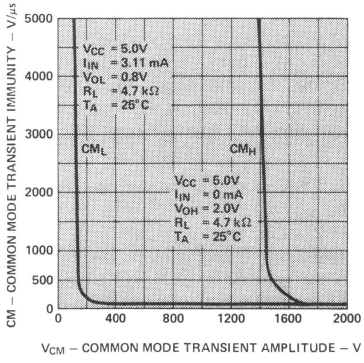
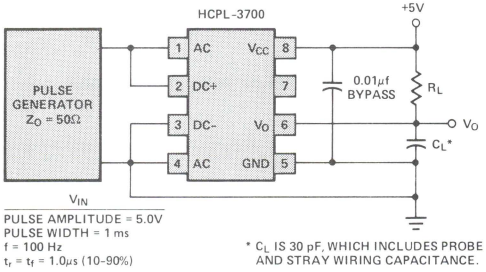


Figure 8. Common Mode Transient Immunity vs. Common Mode Transient Amplitude.



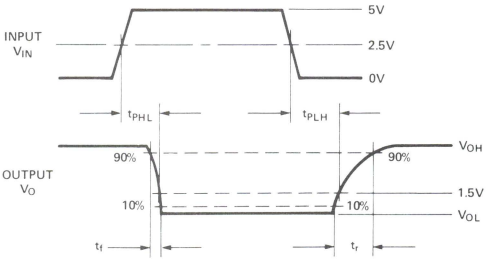
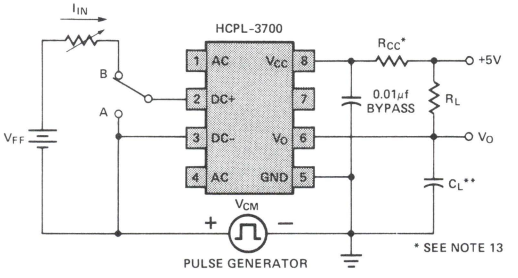


Figure 9. Switching Test Circuit.



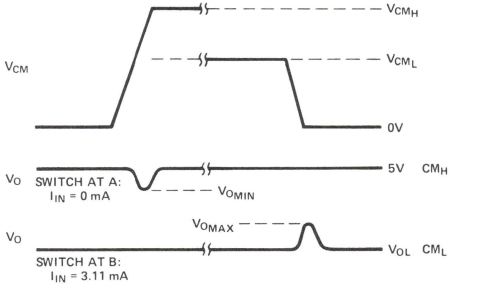


Figure 10. Test Circuit for Common Mode Transient Immunity and Typical Waveforms.

Electrical Considerations

The HCPL-3700 optocoupler has internal temperature compensated, predictable voltage and current threshold points which allow selection of an external resistor, R_x, to determine larger external threshold voltage levels. For a desired external threshold voltage, $V_{\pm}$, a corresponding typical value of R_x can be obtained from Figure 11. Specific calculation of R_x can be obtained from Equation (1) of Figure 12. Specification of both V+ and V− voltage threshold levels simultaneously can be obtained by the use of R_x and R_p as shown in Figure 12 and determined by Equations (2) and (3).

R_x can provide over-current transient protection by limiting input current during a transient condition. For monitoring contacts of a relay or switch, the HCPL-3700 in combination with R_x and R_p can be used to allow a specific current to be conducted through the contacts for cleaning purposes (wetting current).

The choice of which input voltage clamp level to choose depends upon the application of this device (see Figure 1). It is recommended that the low clamp condition be used when possible to lower the input power dissipation as well as the LED current, which minimizes LED degradation over time.

In applications where dV_{CM}/dt may be extremely large (such as static discharge), a series resistor, R_{CC}, should be connected in series with V_{CC} and Pin 8 to protect the detector IC from destructively high surge currents. See note 13 for determination of R_{CC}. In addition, it is recommended that a ceramic disc bypass capacitor of 0.01 μf be placed between Pins 8 and 5 to reduce the effect of power supply noise.

For interfacing AC signals to TTL systems, output low pass filtering can be performed with a pullup resistor of 1.5 kΩ and 20 μf capacitor. This application requires a Schmitt trigger gate to avoid slow rise time chatter problems. For AC input applications, a filter capacitor can be placed across the DC input terminals for either signal or transient filtering.

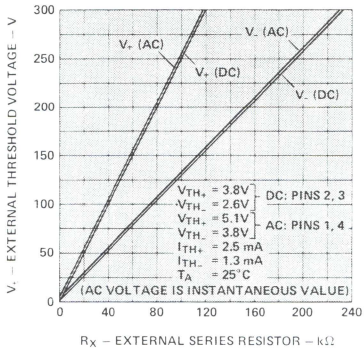


Figure 11. Typical External Threshold Characteristic, $V_{\pm}$ vs. R_X.

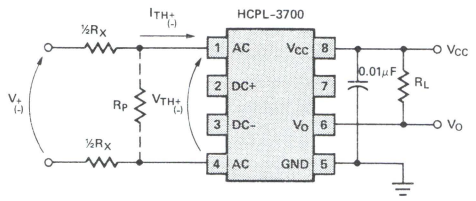


Figure 12. External Threshold Voltage Level Selection.

Either AC (Pins 1, 4) or DC (Pins 2, 3) input can be used to determine external threshold levels.

For one specifically selected external threshold voltage level V+ or V−, R_x can be determined without use of R_p via

$$R_x = \frac{V_{+(-)} - V_{TH+(-)}}{I_{TH+(-)}} \qquad (1)$$

For two specifically selected external threshold voltage levels, V+ and V−, the use of R_x and R_p will permit this selection via equations (2), (3) provided the following conditions are met.

$$\frac{V_+}{V_-} \geq \frac{V_{TH+}}{V_{TH-}} \quad \text{and} \quad \frac{V_+ - V_{TH+}}{V_- - V_{TH-}} < \frac{I_{TH+}}{I_{TH-}}$$

$$R_x = \frac{V_{TH-}(V_+) - V_{TH+}(V_-)}{I_{TH+}(V_{TH-}) - I_{TH-}(V_{TH+})} \qquad (2)$$

$$R_p = \frac{V_{TH-}(V_+) - V_{TH+}(V_-)}{I_{TH+}(V_- - V_{TH-}) + I_{TH-}(V_{TH+} - V_+)} \qquad (3)$$

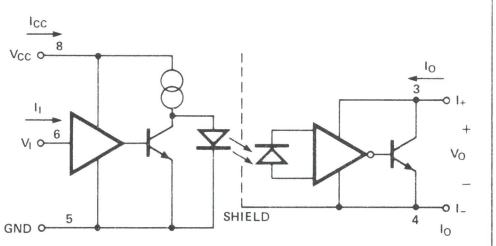
See Application Note 1004 for more information.

HEWLETT PACKARD

OPTICALLY COUPLED 20 mA CURRENT LOOP TRANSMITTER

HCPL-4100

SCHEMATIC

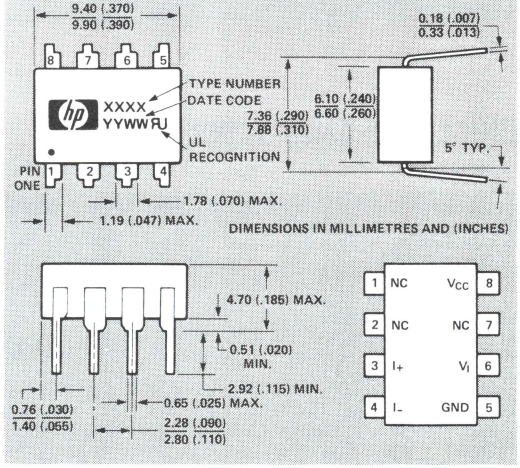


TRUTH TABLE
(POSITIVE LOGIC)*

V_I	V_{CC}	I_O
H	ON	H
L	ON	L
H	OFF	H
L	OFF	H

*CURRENT LOOP CONVENTION – H = MARK: $I_O \geq 12$ mA, L = SPACE: $I_O \leq 2$ mA.

OUTLINE DRAWING*



Features

- **GUARANTEED 20 mA LOOP PARAMETERS**
- **DATA INPUT COMPATIBLE WITH LSTTL, TTL AND CMOS LOGIC**
- **GUARANTEED PERFORMANCE OVER TEMPERATURE (0° C to 70° C)**
- **INTERNAL SHIELD FOR HIGH COMMON MODE REJECTION**
- **20 KBaud DATA RATE AT 400 METRES LINE LENGTH**
- **GUARANTEED ON AND OFF OUTPUT CURRENT LEVELS**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**
- **OPTICALLY COUPLED 20 mA CURRENT LOOP RECEIVER, HCPL-4200, ALSO AVAILABLE**

Applications

- **IMPLEMENT AN ISOLATED 20 mA CURRENT LOOP TRANSMITTER IN:**
  - **Computer Peripherals**
  - **Industrial Control Equipment**
  - **Data Communications Equipment**

Description

The HCPL-4100 optocoupler is designed to operate as a transmitter in equipment using the 20 mA current loop. 20 mA current loop systems conventionally signal a logic high state by transmitting 20 mA of loop current (MARK), and signal a logic low state by allowing no more than a few milliamperes of loop current (SPACE). Optical coupling of the signal from the logic input to the 20 mA current loop breaks ground loops and provides very high immunity to common mode interference.

The HCPL-4100 data input is compatible with LSTTL, TTL, and CMOS logic gates. The input integrated circuit drives a GaAsP LED. The light emitted by the LED is sensed by a second integrated circuit that allows 20 mA to pass with a voltage drop of less than 2.7 volts when no light is emitted and allows less than 2 mA to pass when light is emitted. The transmitter output is capable of withstanding 27 volts. The input integrated circuit provides a controlled amount of LED drive current and takes into account LED light output degradation. The internal shield allows a guaranteed 1000 V/μs common mode transient immunity.

OPTOCOUPLERS

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.5	20	Volts
Input Voltage Low	V_{IL}	0	0.8	Volts
Input Voltage High	V_{IH}	2.0	20	Volts
Operating Temperature	T_A	0	70	°C
Output Voltage	V_O	0	27	Volts
Output Current	I_O	0	24	mA

Absolute Maximum Ratings

(No Derating Required up to 55° C)

Storage Temperature ..... -55° C to 125° C
Operating Temperature ..... -40° C to 85° C
Lead Solder Temperature ..... 260° C for 10 sec.
(1.6 mm below seating plane)
Supply Voltage — V_{CC} ..... 0 to 20 V
Average Output Current — I_O ..... -30 mA to 30 mA
Peak Output Current — I_O ..... internally limited
Output Voltage — V_O ..... -0.4 V to 27 V
Input Voltage — V_I ..... -0.5 V to 20 V
Input Power Dissipation — P_I ..... 265 mW[1]
Output Power Dissipation — P_O ..... 125 mW[2]
Total Power Dissipation — P ..... 360 mW[3]

Electrical Characteristics

for 0° C ≤ T_A ≤ 70° C, 4.5 V ≤ V_{CC} ≤ 20 V, all typicals at T_A = 25° C and V_{CC} = 5 V unless otherwise noted

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions		Fig.	Note
Mark State Output Voltage	V_{MO}		1.8 2.2 2.35	2.25 2.7	Volts Volts Volts	I_O = 2 mA I_O = 12 mA I_O = 20 mA	V_I = 2.0 V	1, 2	
Mark State Short Circuit Output Current	I_{SC}	30	85		mA	V_I = 2 V, V_O = 5 V to 27 V			4
Space State Output Current	I_{SO}	0.5	1.1	2.0	mA	V_I = 0.8 V, V_O = 27 V		3	
Low Level Input Current	I_{IL}		-0.12	-0.32	mA	V_{CC} = 20 V, V_I = 0.4 V			
Low Level Input Voltage	V_{IL}			0.8	Volts				
High Level Input Voltage	V_{IH}	2.0			Volts				
High Level Input Current	I_{IH}		 0.005	20 100 250	μA μA μA	V_I = 2.7 V V_I = 5.5 V V_I = 20 V			
Supply Current	I_{CC}		7.0 7.8	11.5 13	mA mA	V_{CC} = 5.5 V V_{CC} = 20 V	0 V ≤ V_I ≤ 20 V		
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 3 kV dc, T_A = 25° C			5, 6
OPT 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50% t = 1 MIN			13
Resistance (input-output)	R_{I-O}		10^{12}		Ohms	V_{I-O} = 500 V dc			5
Capacitance (input-output)	C_{I-O}		1		pF	f = 1 MHz, V_{I-O} = 0 V dc			5

Notes:
1. Derate linearly above 55° C free air temperature at a rate of 3.8 mW/° C. Proper application of the derating factors will prevent IC junction temperatures from exceeding 125° C for ambient temperatures up to 85° C.
2. Derate linearly above a free-air temperature of 70° C at a rate of 2.3 mW/° C. A significant amount of power may be dissipated in the HCPL-4100 output circuit during the transition from the SPACE state to the MARK state when driving a data line or capacitive load (C_{OUT}). The average power dissipation during the transition can be estimated from the following equation which assumes a linear discharge of a capacitive load: $P = I_{SC}(V_{SO} + V_{MO})/2$, where V_{SO} is the output voltage in the SPACE state. The duration of this transition can be estimated as $t = C_{OUT}(V_{SO} - V_{MO})/I_{SC}$. For typical applications driving twisted pair data lines with NRZ data as shown in Figure 11, the transition time will be less than 10% of one bit time.
3. Derate linearly above 55° C free-air temperature at a rate of 5.1 mW/° C.
4. The maximum current that will flow into the output in the mark state (I_{SC}) is internally limited to protect the device. The duration of the output short circuit shall not exceed 10 ms.
5. The device is considered a two terminal device, pins 1, 2, 3, and 4 are connected together, and pins 5, 6, 7, and 8 are connected together.
6. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.

Switching Characteristics

for $0 \le T_A \le 70°C$, $4.5\ V \le V_{CC} \le 20\ V$, all typicals at $T_A = 25°C$ and $V_{CC} = 5\ V$ unless otherwise noted

Parameter	Symbol	Min.	Typ.	Max.	Units	Testing Conditions	Fig.	Note
Propagation Delay Time to Logic High Output Level	t_{PLH}		0.3	1.6	μs	$C_O = 1000\ pF$, $C_L = 15\ pF$, $I_O = 20\ mA$	4, 5, 6	7
Propagation Delay Time to Logic Low Output Level	t_{PHL}		0.2	1.0	μs	$C_O = 1000\ pF$, $C_L = 15\ pF$, $I_O = 20\ mA$	4, 5, 6	8
Propagation Delay Time Skew	t_{PLH}-t_{PHL}		0.1		μs	$I_O = 20\ mA$		
Output Rise Time (10-90%)	t_r		16		ns	$I_O = 20\ mA$, $C_O = 1000\ pF$, $C_L = 15\ pF$.	5, 7	9
Output Fall Time (90-10%)	t_f		23		ns	$I_O = 20\ mA$, $C_O = 1000\ pF$, $C_L = 15\ pF$.	5, 7	10
Common Mode Transient Immunity at Logic High Output Level	$\lvert CM_H \rvert$	1,000	10,000		V/μs	$V_I = 2\ V$, $T_A = 25°C$ $V_{CM} = 50\ V$ (peak), $V_{CC} = 5\ V$ I_O (min.) = 12 mA	8, 9, 10	11
Common Mode Transient Immunity at Logic Low Output Level	$\lvert CM_L \rvert$	1,000	10,000		V/μs	$V_I = 0.8\ V$, $T_A = 25°C$ $V_{CM} = 50\ V$ (peak), $V_{CC} = 5\ V$ I_O (max.) = 3 mA	8, 9, 10	12

Notes:

7. The t_{PLH} propagation delay is measured from the 1.3 volt level on the leading edge of the input pulse to the 10 mA level on the leading edge of the output pulse.
8. The t_{PHL} propagation delay is measured from the 1.3 volt level on the trailing edge of the input pulse to the 10 mA level on the trailing edge of the output pulse.
9. The rise time, t_r, is measured from the 10% to the 90% level on the rising edge of the output current pulse.
10. The fall time, t_f, is measured from the 90% to the 10% level on the falling edge of the output current pulse.
11. The common mode transient immunity in the logic high level is the maximum (positive) dV_{CM}/dt on the leading edge of the common mode pulse, V_{CM}, that can be sustained with the output in a Mark ("H") state (i.e., $I_O > 12\ mA$).
12. The common mode transient immunity in the logic low level is the maximum (negative) dV_{CM}/dt on the leading edge of the common mode pulse, V_{CM}, that can be sustained with the output in a Space ("L") state (i.e., $I_O > 3\ mA$).
13. See Option 010 data sheet for more information.

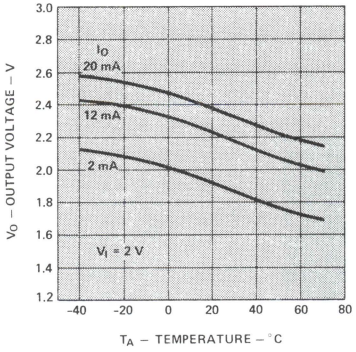


Figure 1. Typical Mark State Output Voltage vs. Temperature

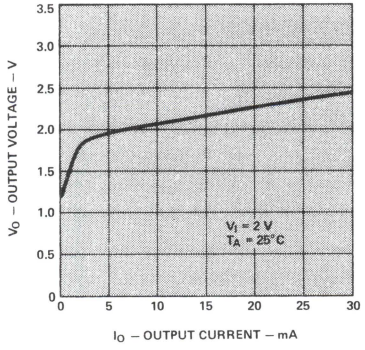


Figure 2. Typical Output Voltage vs. Output Current in Mark State

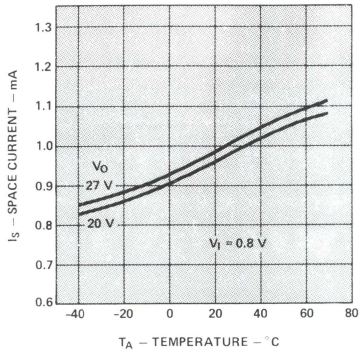


Figure 3. Typical Space State Output Current vs. Temperature

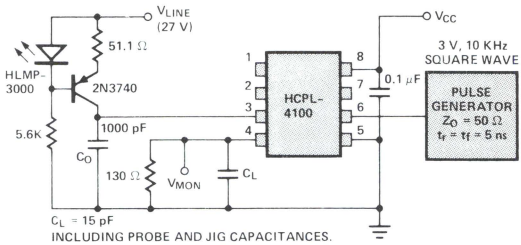


Figure 4. Test Circuit for t_{PLH}, t_{PHL}, t_r, and t_f

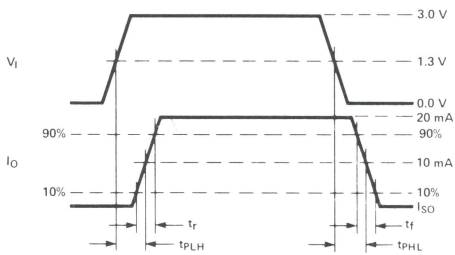


Figure 5. Waveforms for t_{PLH}, t_{PHL}, t_r, and t_f

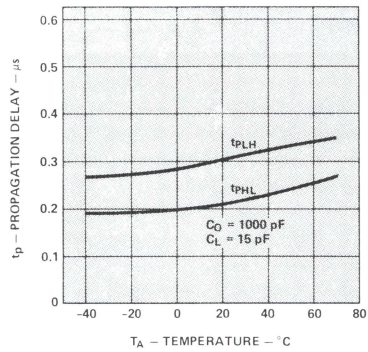


Figure 6. Typical Propagation Delay vs. Temperature

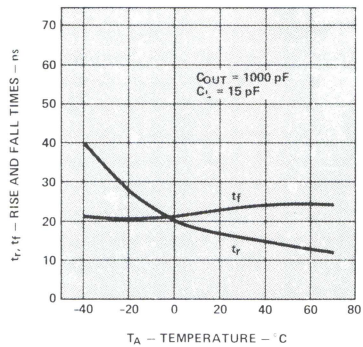


Figure 7. Typical Rise, Fall Times vs. Temperature

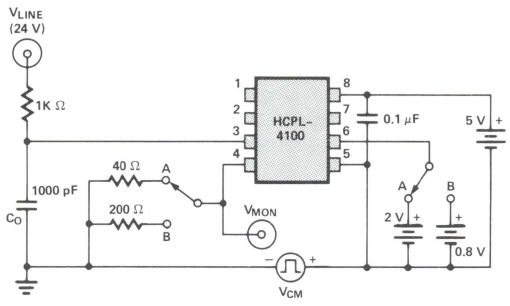


Figure 8. Test Circuit for Common Mode Transient Immunity

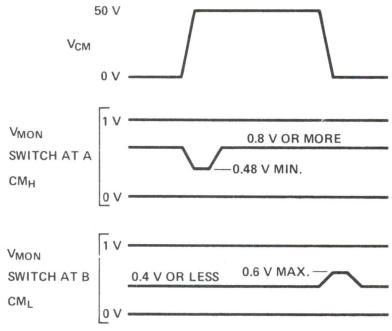


Figure 9. Typical Waveforms for Common Mode Transient Immunity

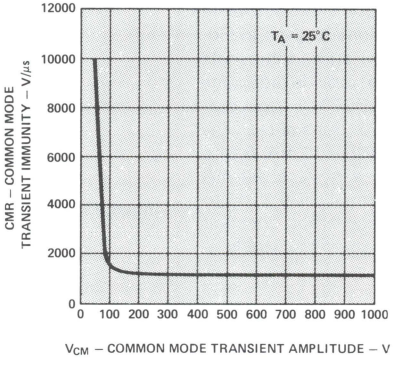


Figure 10. Common Mode Transient Immunity vs. Common Mode Transient Amplitude

Applications

Data transfer between equipment which employs current loop circuits can be accomplished via one of three configurations: simplex, half duplex or full duplex communication. With these configurations, point to point and multidrop arrangements are possible. The appropriate configuration to use depends upon data rate, number of stations, number and length of lines, direction of data flow, protocol, current source location and voltage compliance value, etc.

SIMPLEX

The simplex configuration, whether point to point or multidrop, gives unidirectional data flow from transmitter(s) to receiver. This is the simplest configuration for use in long line length (two wire), moderate data rate, and low current source compliance level applications. A block diagram of simplex point to point arrangement is given in Figure 11 for the HCPL-4100 transmitter optocoupler.

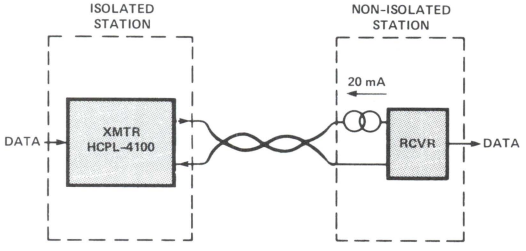


Figure 11. Simplex Point to Point Current Loop System Configuration

Major factors which limit maximum data rate performance for a simplex loop are the location and compliance voltage of the loop current source as well as the total line capacitance. Application of the HCPL-4100 transmitter in a simplex loop necessitates that a non-isolated active receiver (containing current source) be used at the opposite end of the current loop. With long line length, large line capacitance will need to be charged to the compliance voltage level of the current source before the receiver loop current decreases to zero. This effect limits upper data rate performance. Slower data rates will occur with larger compliance voltage levels. The maximum compliance level is determined by the transmitter breakdown characteristic. In addition, adequate compliance of the current source must be available for voltage drops across station(s) during the MARK state in multidrop applications for long line lengths.

In a simplex multidrop application with multiple HCPL-4100 transmitters and one non-isolated active receiver, priority of transmitters must be established.

A recommended non-isolated active receiver circuit which can be used with the HCPL-4100 in point to point or in multidrop 20 mA current loop applications is given in Figure 12. This non-isolated active receiver current threshold must be chosen properly in order to provide adequate noise immunity as well as not to detect SPACE state current (bias current) of the HCPL-4100 transmitter. The receiver input threshold current is Vth/Rth ≈ 10 mA. A simple transistor current source provides a nominal 20 mA loop current over a V_{CC} compliance range of 6 V dc to 27 V dc. A resistor can be used in place of the constant current source for simple applications where the wire loop distance and number of stations on the loop are fixed. A minimum transmitter output load capacitance of 1000 pF is required between pins 3 and 4 to ensure absolute stability.

Length of the current loop (one direction) versus minimum required DC supply voltage, V_{CC}, of the circuit in Figure 12 is graphically illustrated in Figure 13. Multidrop configurations will require larger V_{CC} than Figure 13 predicts in order to account for additional station terminal voltage drops.

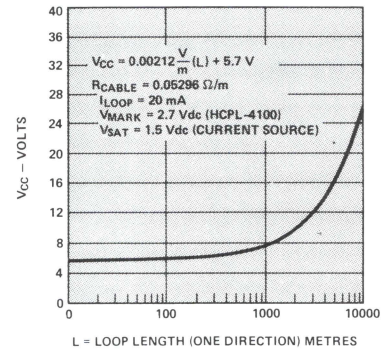


Figure 13. Minimum Required Supply Voltage, V_{CC}, vs. Loop Length for Current Loop Circuit of Figure 12

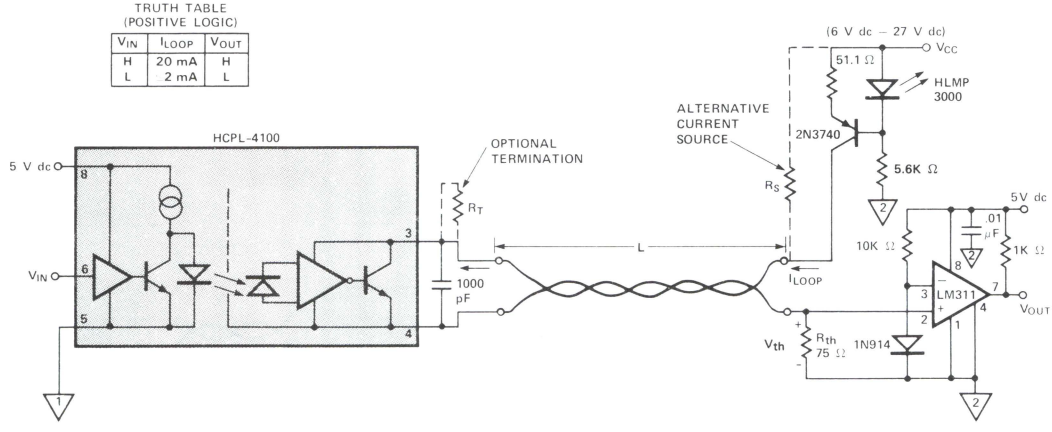


Figure 12. Recommended Non-Isolated Active Receiver with HCPL-4100 Isolated Transmitter for Simplex Point to Point 20 mA Current Loop

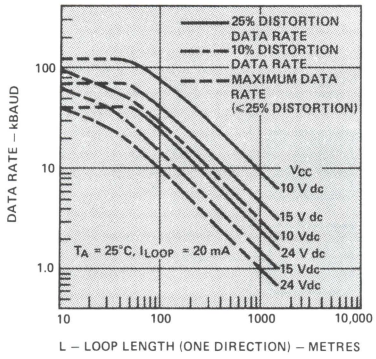


Figure 14. Typical Data Rate vs. Distance and Supply Voltage

Typical data rate performance versus distance is illustrated in Figure 14 for the combination of a non-isolated active receiver and HCPL-4100 optically coupled current loop transmitter shown in Figure 12. Curves are shown for 25% distortion data rate at different V_{CC} values. 25% distortion data rate is defined as that rate at which 25% distortion occurs to output bit interval with respect to the input bit interval. Maximum data rate (dotted line) is restricted by device characteristics. An input Non-Return-to-Zero (NRZ) test waveform of 16 bits (0000001011111101) was used for data rate distortion measurements. Enhanced speed performance of the loop system can be obtained with lower V_{CC} supply levels, as illustrated in Figure 14. In addition, when loop current is supplied through a resistor instead of by a current source, an additional series termination resistance equal to the characteristic line impedance can be used at the HCPL-4100 transmitter end to enhance speed of response by approximately 20%.

The cable used contained five pairs of unshielded, twisted, 22 AWG wire (Dearborn #862205). Loop current is 20 mA nominal. Input and output logic supply voltages are 5 V dc.

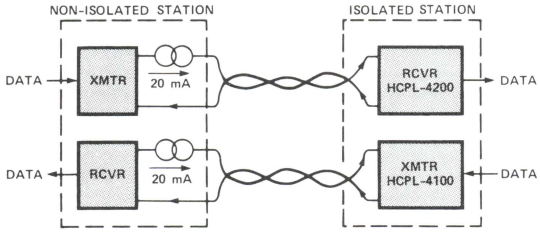


Figure 15. Full Duplex Point to Point Current Loop System Configuration

FULL DUPLEX

Full duplex point to point communication of Figure 15 uses a four wire system to provide simultaneous, bi-directional data communication between local and remote equipment. Basic application uses two simplex point to point loops which have two separate, active, non-isolated units at one common end of the loops. The other end of each loop is isolated.

As Figure 15 illustrates, the combination of Hewlett-Packard current loop optocouplers, HCPL-4100 transmitter and HCPL-4200 receiver, can be used at the isolated end of current loops. Cross talk and common mode coupling are greatly reduced when optical isolation is implemented at the same end of both loops, as shown. Full duplex data rate is limited by the non-isolated active receiver current loop. Comments mentioned under simplex configuration apply to the full duplex case. Consult the HCPL-4200 receiver optocoupler data sheet for specified device performance.

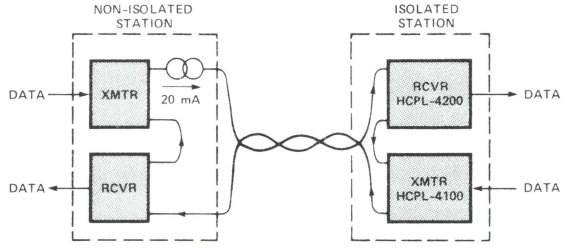
HALF DUPLEX

The half duplex configuration, whether point to point or multidrop, gives non-simultaneous bidirectional data flow from transmitters to receivers shown in Figures 16a and 16b. This configuration allows the use of two wires to carry data back and forth between local and remote units. However, protocol must be used to determine which specific transmitter can operate at any given time. Maximum data rate for a half duplex system is limited by the loop current charging time. These considerations were explained in the Simplex configuration section.

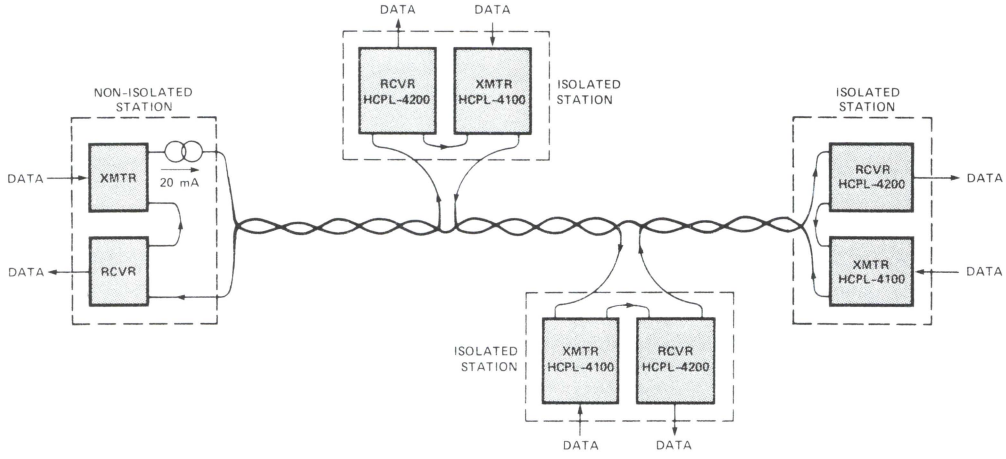
Figures 16a and 16b illustrate half duplex application for the combination of HCPL-4100/-4200 optocouplers. The unique and complementary designs of the HCPL-4100 transmitter and HCPL-4200 receiver optocouplers provide many designed-in benefits. For example, total optical isolation at one end of the current loop is easily accomplished, which results in substantial removal of common mode influences, elimination of ground potential differences and reduction of power supply requirements. With this combination of HCPL-4100/-4200 optocouplers, specific current loop noise immunity is provided, i.e., minimum SPACE state current noise immunity is 1 mA, MARK state noise immunity is 8 mA.

Voltage compliance of the current source must be of an adequate level for operating all units in the loop while not exceeding 27 V dc, the maximum breakdown voltage for the HCPL-4100. Note that the HCPL-4100 transmitter will allow output loop current to conduct when input V_{CC} power is off. Consult the HCPL-4200 receiver optocoupler data sheet for specified device performance.

For more informaton about the HCPL-4100/-4200 optocouplers, consult Application Note 1018.



(a) POINT TO POINT



(b) MULTIDROP

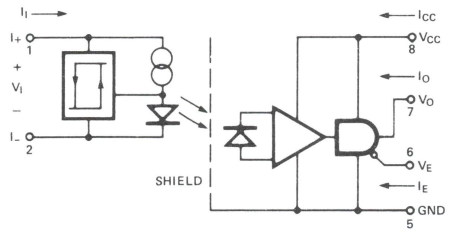
Figure 16. Half Duplex Current Loop System Configurations for (a) Point to Point, (b) Multidrop

HEWLETT PACKARD

OPTICALLY COUPLED 20 mA CURRENT LOOP RECEIVER

HCPL-4200

SCHEMATIC

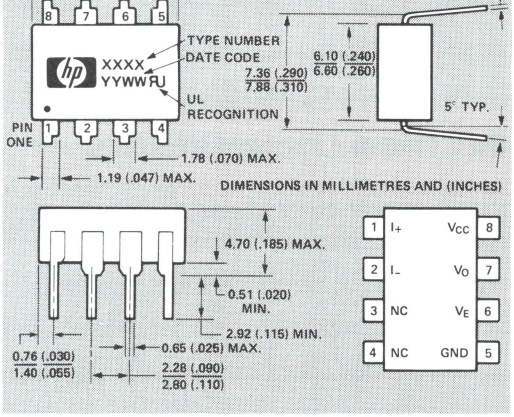


TRUTH TABLE (POSITIVE LOGIC)*

I_I	V_E	V_O
H	H	Z
L	H	Z
H	L	H
L	L	L

*CURRENT LOOP CONVENTION – H = MARK: $I_I \geq 12$ mA, L = SPACE: $I_I \leq 3$ mA, Z = OFF (HIGH IMPEDANCE) STATE.

OUTLINE DRAWING*



Features

- **DATA OUTPUT COMPATIBLE WITH LSTTL, TTL, AND CMOS**
- **20K BAUD DATA RATE AT 1400 METRES LINE LENGTH**
- **GUARANTEED PERFORMANCE OVER TEMPERATURE (0° C TO 70° C)**
- **GUARANTEED ON AND OFF THRESHOLDS**
- **LED IS PROTECTED FROM EXCESS CURRENT**
- **INPUT THRESHOLD HYSTERESIS**
- **THREE-STATE OUTPUT COMPATIBLE WITH DATA BUSES**
- **INTERNAL SHIELD FOR HIGH COMMON MODE REJECTION**
- **RECOGNIZED UNDER THE COMPONENT PROGRAM OF U.L. (FILE NO. E55361) FOR DIELECTRIC WITHSTAND PROOF TEST VOLTAGES OF 1440 Vac, 1 MINUTE AND 2500 Vac, 1 MINUTE (OPTION 010).**
- **OPTICALLY COUPLED 20 mA CURRENT LOOP TRANSMITTER, HCPL-4100, ALSO AVAILABLE**

Applications

- **IMPLEMENT AN ISOLATED 20 mA CURRENT LOOP RECEIVER IN:**
  - **Computer Peripherals**
  - **Industrial Control Equipment**
  - **Data Communications Equipment**

Description

The HCPL-4200 optocoupler is designed to operate as a receiver in equipment using the 20 mA Current Loop. 20 mA current loop systems conventionally signal a logic high state by transmitting 20 mA of loop current (MARK), and signal a logic low state by allowing no more than a few milliamperes of loop current (SPACE). Optical coupling of the signal from the 20 mA current loop to the logic output breaks ground loops and provides for a very high common mode rejection. The HCPL-4200 aids in the design process by providing guaranteed thresholds for logic high state and logic low state for the current loop, providing an LSTTL, TTL, or CMOS compatible logic interface, and providing guaranteed common mode rejection. The buffer circuit on the current loop side of the HCPL-4200 provides typically 0.8 mA of hysteresis which increases the immunity to common mode and differential mode noise. The buffer also provides a controlled amount of LED drive current which takes into account LED light output degradation. The internal shield allows a guaranteed 1000 V/μs common mode transient immunity.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.5	20	Volts
Forward Input Current (SPACE)	I_{SI}	0	2.0	mA
Forward Input Current (MARK)	I_{MI}	14	24	mA
Operating Temperature	T_A	0	70	°C
Fan Out	N	0	4	TTL Loads
Logic Low Enable Voltage	V_{EL}	0	0.8	Volts
Logic High Enable Voltage	V_{EH}	2.0	20	Volts

Absolute Maximum Ratings

(No Derating Required up to 70° C)

Storage Temperature ..... —55° C to 125° C
Operating Temperature ..... —40° C to 85° C
Lead Solder Temperature ..... 260° C for 10 sec.
(1.6 mm below the seating plane)
Supply Voltage — V_{CC} ..... 0 V to 20 V
Average Input Current — I_I ..... —30 mA to 30 mA
Peak Transient Input Current — I_I ..... 0.5 A[1]
Enable Input Voltage — V_E ..... —0.5 V to 20 V
Output Voltage — V_O ..... —0.5 V to 20 V
Average Output Current — I_O ..... 25 mA
Input Power Dissipation — P_I ..... 90 mW[2]
Output Power Dissipation — P_O ..... 210 mW[3]
Total Power Dissipation — P ..... 255 mW[4]

Electrical Characteristics

For 0° C ≤ T_A ≤ 70° C, 4.5 V ≤ V_{CC} ≤ 20 V, V_E = 0.8 V, all typicals at T_A = 25° C and V_{CC} = 5 V unless otherwise noted

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Mark State Input Current	I_{MI}	12			mA		1, 2, 3	
Mark State Input Voltage	V_{MI}		2.52	2.75	Volts	I_I = 20 mA, V_E = Don't Care	3, 4	
Space State Input Current	I_{SI}			3	mA		1, 2, 3	
Space State Input Voltage	V_{SI}		1.6	2.2	Volts	I_I = 0.5 to 2.0mA, V_E = Don't Care	1, 3	
Input Hysteresis Current	I_{HYS}	0.3	0.8		mA		1	
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 6.4 mA (4 TTL Loads) I_I = 3 mA	5	
Logic High Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -2.6 mA, I_I = 12 mA	6	
Output Leakage Current (V_{OUT} > V_{CC})	I_{OHH}			100	μA	V_O = 5.5 V; I_I = 20 mA		
				500	μA	V_O = 20 V; V_{CC} = 4.5 V		
Logic High Enable Voltage	V_{EH}	2.0			Volts			
Logic Low Enable Voltage	V_{EL}			0.8	Volts			
Logic High Enable Current	I_{EH}			20	μA	V_E = 2.7 V		
				100	μA	V_E = 5.5 V		
			.004	250	μA	V_E = 20 V		
Logic Low Enable Current	I_{EL}			-0.32	mA	V_E = 0.4 V		
Logic Low Supply Current	I_{CCL}		4.5	6.0	mA	V_{CC} = 5.5 V; I_I = 0 mA		
			5.25	7.5	mA	V_{CC} = 20 V; V_E = Don't Care		
Logic High Supply Current	I_{CCH}		2.7	4.5	mA	V_{CC} = 5.5 V; I_I = 20 mA		
			3.1	6.0	mA	V_{CC} = 20 V; V_E = Don't Care		
High Impedance State Output Current	I_{OZL}			-20	μA	V_O = 0.4 V; V_E = 2.0 V, I_I = 20 mA		
	I_{OZH}			20	μA	V_O = 2.4 V; V_E = 2 V, I_I = 0 mA		
				100	μA	V_O = 5.5 V		
				500	μA	V_O = 20 V		
Logic Low Short Circuit Output Current	I_{OSL}	25			mA	V_O = V_{CC} = 5.5 V; I_I = 0 mA		
		40			mA	V_O = V_{CC} = 20 V; I_I = 0 mA		5
Logic High Short Circuit Output Current	I_{OSH}	-10			mA	V_{CC} = 5.5 V; I_I = 20 mA		
		-25			mA	V_{CC} = 20 V; V_O = GND		5
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 3kV dc, T_A = 25° C		6, 7
OPT. 010	V_{ISO}	2500			V_{RMS}	RH ≤ 50%, t = 1 min.		14
Input-Output Resistance	R_{I-O}		10^{12}		ohms	V_{I-O} = 500 V dc		6
Input-Output Capacitance	C_{I-O}		1.0		pF	f = 1 MHz, V_{I-O} = 0 V dc		6
Input Capacitance	C_{IN}		120		pF	f = 1 MHz, V_I = 0 V dc, Pins 1 and 2		

Switching Characteristics

For $0°C \leq T_A \leq 70°C$, $4.5\ V \leq V_{CC} \leq 20\ V$, $V_E = 0.8\ V$, all typicals at $T_A = 25°C$ and $V_{CC} = 5\ V$ unless otherwise noted

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Propagation Delay Time to Logic High Output Level	t_{PLH}		0.23	1.6	μs	$V_E = 0\ V$, $C_L = 15\ pF$	7, 8, 9	8
Propagation Delay Time to Logic Low Output Level	t_{PHL}		0.17	1.0	μs	$V_E = 0\ V$, $C_L = 15\ pF$	7, 8, 9	9
Propagation Delay Time Skew	t_{PLH}-t_{PHL}		60		ns	$I_I = 20\ mA$, $C_L = 15\ pF$	7, 8, 9	
Output Enable Time to Logic Low Level	t_{PZL}		25		ns	$I_I = 0\ mA$, $C_L = 15\ pF$	11, 12, 14	
Output Enable Time to Logic High Level	t_{PZH}		28		ns	$I_I = 20\ mA$, $C_L = 15\ pF$	11, 12, 13	
Output Disable Time from Logic Low Level	t_{PLZ}		60		ns	$I_I = 0\ mA$, $C_L = 15\ pF$	11, 12, 14	
Output Disable Time from Logic High Level	t_{PHZ}		105		ns	$I_I = 20\ mA$, $C_L = 15\ pF$	11, 12, 13	
Output Rise Time (10-90%)	t_r		55		ns	$V_{CC} = 5\ V$, $C_L = 15\ pF$	7, 8, 10	10
Output Fall Time (90-10%)	t_f		15		ns	$V_{CC} = 5\ V$, $C_L = 15\ pF$	7, 8, 10	11
Common Mode Transient Immunity at Logic High Output Level	$\|CM_H\|$	1,000	10,000		V/μs	$V_{CM} = 50\ V$ (peak) $I_I = 12\ mA$, $T_A = 25°C$	15, 16	12
Common Mode Transient Immunity at Logic Low Output Level	$\|CM_L\|$	1,000	10,000		V/μs	$V_{CM} = 50\ V$ (peak) $I_I = 3\ mA$, $T_A = 25°C$	15, 16	13

NOTES:

1. $\leq 1\ \mu s$ pulse width, 300 pps.
2. Derate linearly above 70° C free air temperature at a rate of 1.6 mW/° C. Proper application of the derating factors will prevent IC junction temperatures from exceeding 125° C for ambient temperatures up to 85° C.
3. Derate linearly above 70° C free air temperature at a rate of 3.8 mW/° C.
4. Derate linearly above 70° C free air temperature at a rate of 4.6 mW/° C.
5. Duration of output short circuit time shall not exceed 10 ms.
6. The device is considered a two terminal device, pins 1, 2, 3, and 4 are connected together and pins 5, 6, 7, and 8 are connected together.
7. This is a proof test. This rating is equally validated by a 2500 Vac, 1 sec. test.
8. The t_{PLH} propagation delay is measured from the 10 mA level on the leading edge of the input pulse to the 1.3 V level on the leading edge of the output pulse.
9. The t_{PHL} propagation delay is measured from the 10 mA level on the trailing edge of the input pulse to the 1.3 V level on the trailing edge of the output pulse.
10. The rise time, t_r, is measured from the 10% to the 90% level on the rising edge of the output logic pulse.
11. The fall time, t_f, is measured from the 90% to the 10% level on the falling edge of the output logic pulse.
12. Common mode transient immunity in the logic high level is the maximum (negative) dV_{CM}/dt on the trailing edge of the common mode pulse, V_{CM}, which can be sustained with the output voltage in the logic high state (i.e., $V_O \geq 2\ V$).
13. Common mode transient immunity in the logic low level is the maximum (positive) dV_{CM}/dt on the leading edge of the common mode pulse, V_{CM}, which can be sustained with the output voltage in the logic low state (i.e., $V_O \leq 0.8\ V$).
14. See Option 010 data sheet for more information.

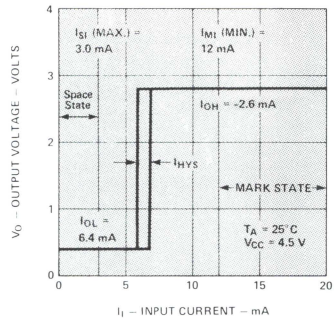


Figure 1. Typical Output Voltage vs. Loop Current

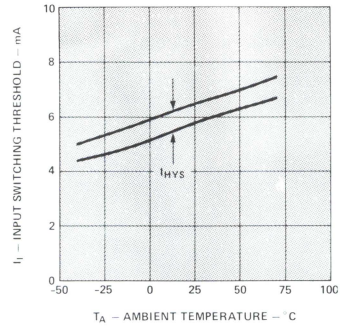


Figure 2. Typical Current Switching Threshold vs. Temperature

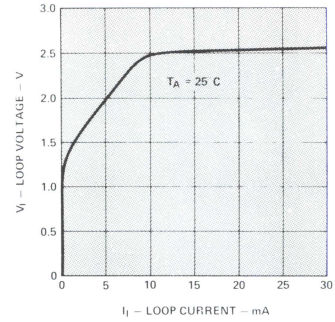


Figure 3. Typical Input Loop Voltage vs. Input Current

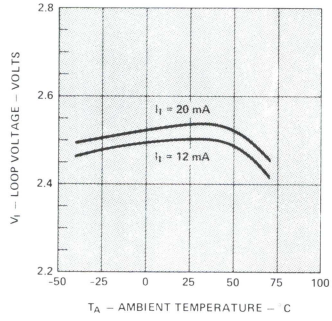


Figure 4. Typical Input Voltage vs. Temperature

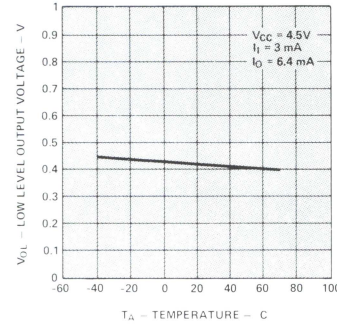


Figure 5. Typical Logic Low Output Voltage vs. Temperature

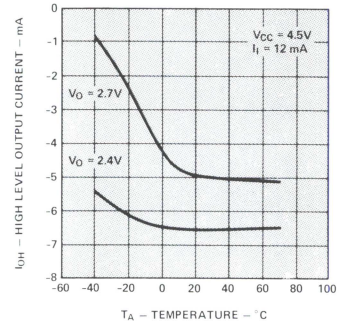
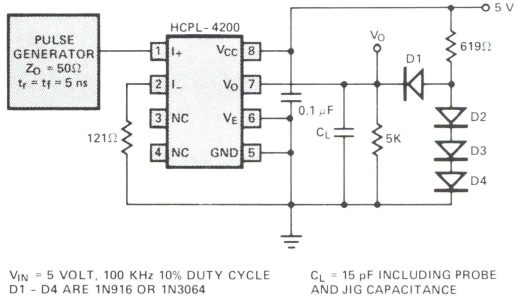


Figure 6. Typical Logic High Output Current vs. Temperature



V_{IN} = 5 VOLT, 100 KHz 10% DUTY CYCLE
D1 - D4 ARE 1N916 OR 1N3064

C_L = 15 pF INCLUDING PROBE AND JIG CAPACITANCE

Figure 7. Test Circuit for t_{PHL}, t_{PLH}, t_r, and t_f

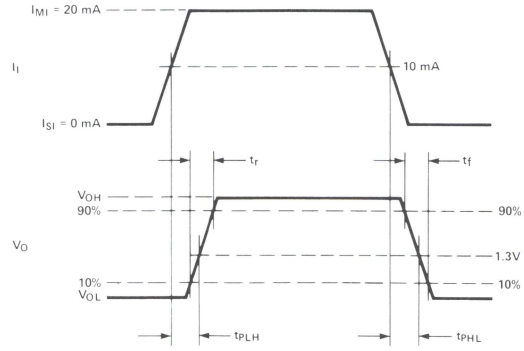


Figure 8. Waveforms for t_{PHL}, t_{PLH}, t_r, and t_f

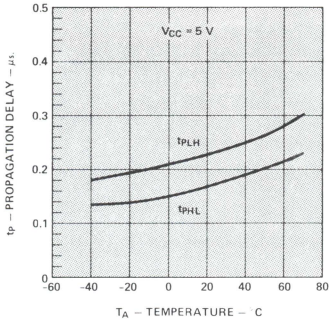


Figure 9. Typical Propagation Delay vs. Temperature

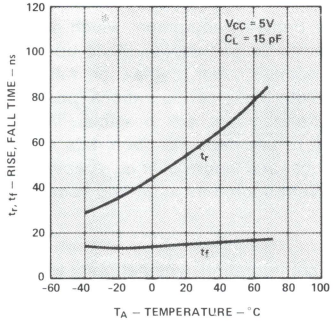


Figure 10. Typical Rise, Fall Time vs. Temperature

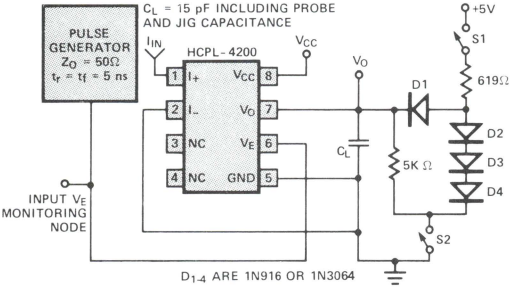


Figure 11. Test Circuit for t_{PZH}, t_{PZL}, t_{PHZ}, and t_{PLZ}

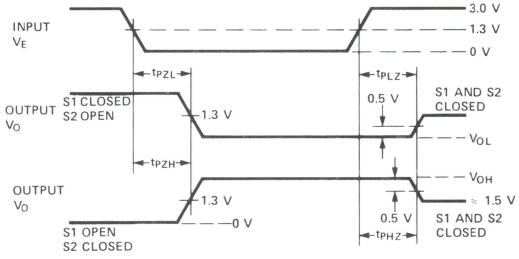


Figure 12. Waveforms for t_{PZH}, t_{PZL}, t_{PHZ}, and t_{PLZ}

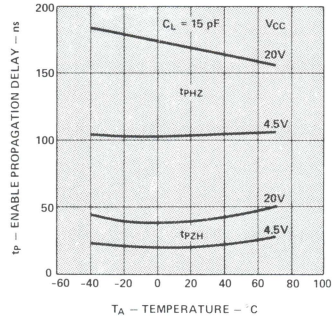


Figure 13. Typical Logic High Enable Propagation Delay vs. Temperature

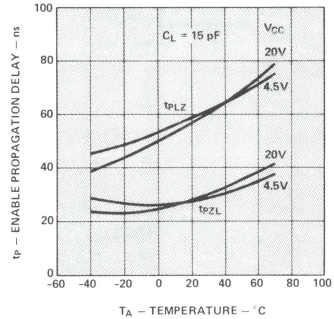


Figure 14. Typical Logic Low Enable Propagation Delay vs. Temperature

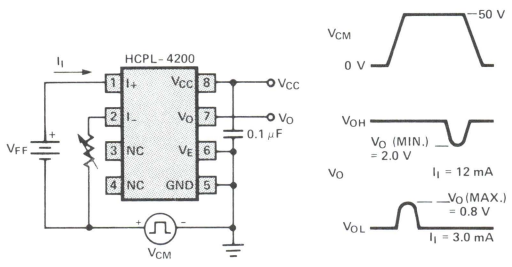


Figure 15. Test Circuit for Common Mode Transient Immunity

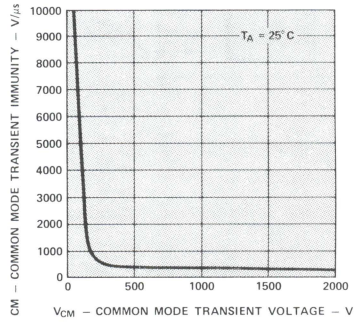


Figure 16. Typical Common Mode Transient Immunity vs. Common Mode Transient Amplitude

Applications

Data transfer between equipment which employs current loop circuits can be accomplished via one of three configurations: simplex, half duplex or full duplex communication. With these configurations, point-to-point and multidrop arrangements are possible. The appropriate configuration to use depends upon data rate, number of stations, number and length of lines, direction of data flow, protocol, current source location and voltage compliance value, etc.

SIMPLEX

The simplex configuration, whether point to point or multidrop, gives unidirectional data flow from transmitter to receiver(s). This is the simplest configuration for use in long line length (two wire), for high data rate, and low current source compliance level applications. Block diagrams of simplex point-to-point and multidrop arrangements are given in Figures 17a and 17b respectively for the HCPL-4200 receiver optocoupler.

For the highest data rate performance in a current loop, the configuration of a non-isolated active transmitter (containing current source) transmitting data to a remote isolated receiver(s) should be used. When the current source is located at the transmitter end, the loop is charged approximately to V_{MI} (2.5 V). Alternatively, when the current source is located at the receiver end, the loop is charged to the full compliance voltage level. The lower the charged voltage level the faster the data rate will be. In the configurations of Figures 17a and 17b, data rate is independent of the current source voltage compliance level. An adequate compliance level of current source must be available for voltage drops across station(s) during the MARK state in multidrop applications or for long line length. The maximum compliance level is determined by the transmitter breakdown characteristic.

A recommended non-isolated active transmitter circuit which can be used with the HCPL-4200 in point-to-point or in multidrop 20 mA current loop applications is given in Figure 18. The current source is controlled via a standard TTL 7407 buffer to provide high output impedance of current source in both the ON and OFF states. This non-isolated active transmitter provides a nominal 20 mA loop current for the listed values of V_{CC}, R2 and R3 in Figure 18.

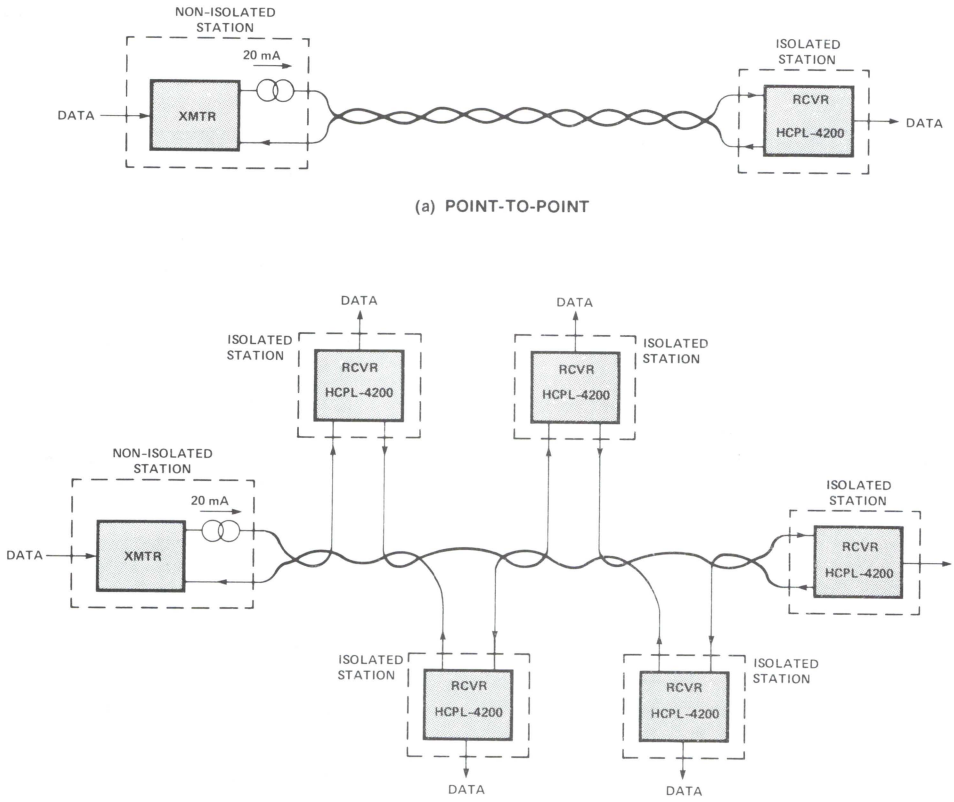


Figure 17. Simplex Current Loop System Configurations for (a) Point-to-Point, (b) Multidrop

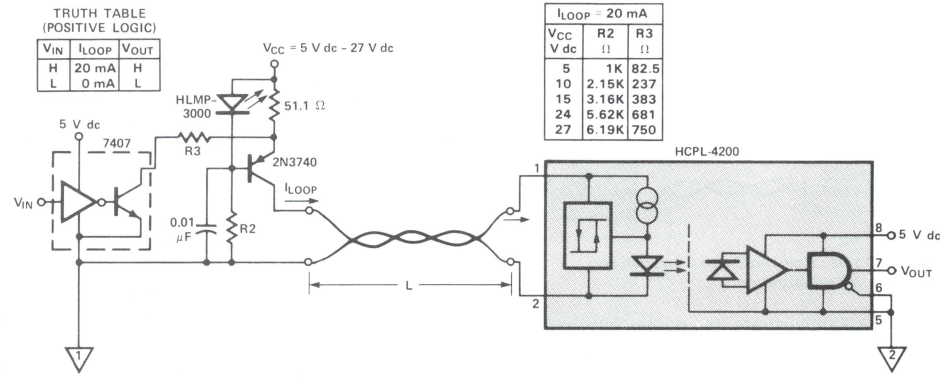


Figure 18. Recommended Non-Isolated Active Transmitter with HCPL-4200 Isolated Receiver for Simplex Point-to-Point 20 mA Current Loop

Length of current loop (one direction) versus minimum required DC supply voltage, V_{CC}, of the circuit in Figure 18 is graphically illustrated in Figure 19. Multidrop configurations will require larger V_{CC} than Figure 19 predicts in order to account for additional station terminal voltage drops.

Typical data rate performance versus distance is illustrated in Figure 20 for the combination of a non-isolated active transmitter and HCPL-4200 optically coupled current loop receiver shown in Figure 18. Curves are shown for 10% and 25% distortion data rate. 10% (25%) distortion data rate is defined as that rate at which 10% (25%) distortion occurs to output bit interval with respect to input bit interval. An input Non-Return-to-Zero (NRZ) test waveform of 16 bits (0000001011111101) was used for data rate distortion measurements. Data rate is independent of current source supply voltage, V_{CC}.

The cable used contained five pairs of unshielded, twisted, 22 AWG wire (Dearborn #862205). Loop current is 20 mA nominal. Input and output logic supply voltages are 5 V dc.

FULL DUPLEX

The full duplex point-to-point communication of Figure 21 uses a four wire system to provide simultaneous, bi-directional data communication between local and remote equipment. The basic application uses two simplex point-to-point loops which have two separate, active, non-isolated units at one common end of the loops. The other end of each loop is isolated.

As Figure 21 illustrates, the combination of Hewlett-Packard current loop optocouplers, HCPL-4100 transmitter and HCPL-4200 receiver, can be used at the isolated end of current loops. Cross talk and common mode coupling are greatly reduced when optical isolation is implemented at the same end of both loops, as shown. The full duplex data rate is limited by the non-isolated active receiver current loop. Comments mentioned under simplex configuration apply to the full duplex case. Consult the HCPL-4100 transmitter optocoupler data sheet for specified device performance.

HALF DUPLEX

The half duplex configuration, whether point-to-point or multidrop, gives non-simultaneous bidirectional data flow from transmitters to receivers shown in Figures 22a and 22b. This configuration allows the use of two wires to carry data back and forth between local and remote units. However, protocol must be used to determine which specific transmitter can operate at any given time. Maximum data rate for a half duplex system is limited by the loop current charging time. These considerations were explained in the Simplex configuration section.

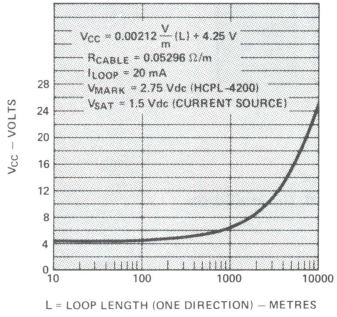


Figure 19. Minimum Required Supply Voltage, V_{CC}, vs. Loop Length for Current Loop Circuit of Figure 18

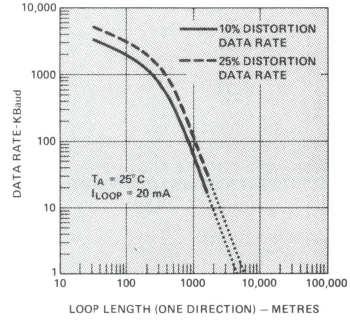


Figure 20. Typical Data Rate vs. Distance

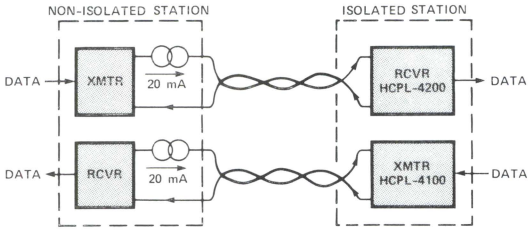
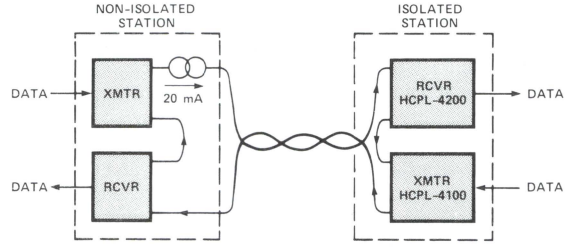


Figure 21. Full Duplex Point-to-Point Current Loop System Configuration

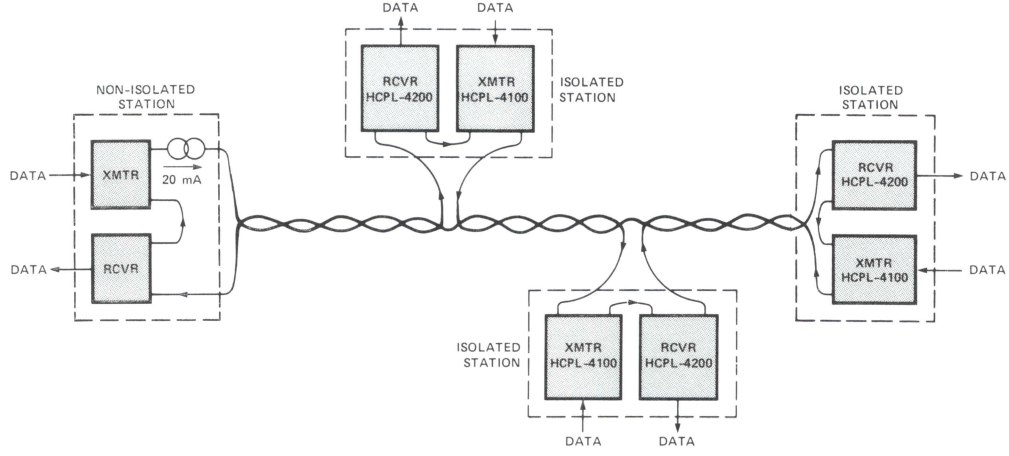
Figures 22a and 22b illustrate half duplex application for the combination of HCPL-4100/-4200 optocouplers. The unique and complementary designs of the HCPL-4100 transmitter and HCPL-4200 receiver optocouplers provide many designed-in benefits. For example, total optical isolation at one end of the current loop is easily accomplished, which results in substantial removal of common mode influences, elimination of ground potential differences and reduction of power supply requirements. With this combination of HCPL-4100/-4200 optocouplers, specific current loop noise immunity is provided, i.e., minimum SPACE state current noise immunity is 1 mA, MARK state noise immunity is 8 mA.

Voltage compliance of the current source must be of an adequate level for operating all units in the loop while not exceeding 27 V dc, the maximum breakdown voltage for the HCPL-4100. Note that the HCPL-4100 transmitter will allow loop current to conduct when input V_{CC} power is off. Consult the HCPL-4100 transmitter optocoupler data sheet for specified device performance.

For more information about the HCPL-4100/-4200 optocouplers, consult Application Note 1018.



(a) POINT-TO-POINT



(b) MULTIDROP

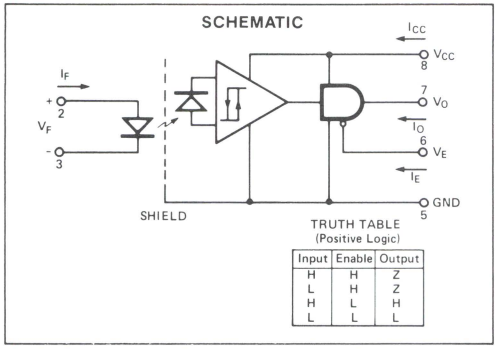
Figure 22. Half Duplex Current Loop System Configurations for (a) Point-to-Point, (b) Multidrop

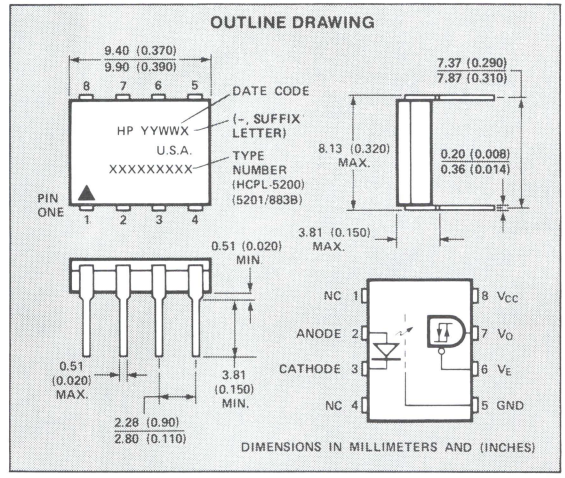
Hermetic Optocouplers

HEWLETT PACKARD

WIDE SUPPLY VOLTAGE, HIGH CMR, HERMETICALLY SEALED OPTOCOUPLER

HCPL-5200
HCPL-5201
(883B)





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- HERMETICALLY SEALED 8 PIN DUAL IN-LINE PACKAGE
- PERFORMANCE GUARANTEED OVER -55° C TO +125° C AMBIENT TEMPERATURE RANGE
- WIDE V_{CC} RANGE (4.5 TO 20 VOLTS)
- MIL-STD-883 CLASS B TESTING
- 500 Vdc WITHSTAND TEST VOLTAGE
- COMPATIBLE WITH LSTTL, TTL, AND CMOS LOGIC
- 300 ns PROPAGATION DELAY GUARANTEED OVER TEMPERATURE
- HCPL-2200 FUNCTION COMPATIBILITY
- THREE STATE OUTPUT (NO PULLUP RESISTOR REQUIRED)
- INTERNAL SHIELD FOR HIGH COMMON MODE REJECTION — 1000 V/μs GUARANTEED

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- ISOLATION OF HIGH SPEED LOGIC SYSTEMS
- COMPUTER-PERIPHERAL INTERFACES
- MICROPROCESSOR SYSTEM INTERFACES
- GROUND LOOP ELIMINATION
- PULSE TRANSFORMER REPLACEMENT
- ISOLATED BUS DRIVER
- HIGH SPEED LINE RECEIVER

Description

The HCPL-5200 and 5201 units are hermetically sealed, logic gate optocouplers. The products are capable of operation and storage over the full military temperature range and can be purchased as either a standard product (HCPL-5200) or with full MIL-STD-883 Class Level B testing (HCPL-5201). Both products are in eight pin hermetic dual in-line packages.

Each unit contains an AlGaAs light emitting diode which is optically coupled to an integrated high gain photon detector. The detector has a three state output stage and has a detector threshold with hysteresis. The three state output eliminates the need for a pullup resistor and allows for direct drive of data busses. The hysteresis provides differential mode noise immunity and eliminates the potential for output signal chatter. The detector IC has an internal shield that provides a guaranteed common mode transient immunity of 1,000 Volts/μsec. Improved power supply rejection eliminates the need for special power supply bypassing precautions.

The HCPL-5200 and HCPL-5201 are guaranteed to operate over a V_{CC} range of 4.5 Volts to 20 Volts. Low I_F and wide V_{CC} range allow compatibility with TTL, LSTTL, and CMOS Logic. Low I_F and low I_{CC} result in lower power consumption compared to other high speed optocouplers. Logic signals are transmitted with a typical propagation delay of 100 nsec when used in the circuit of Figure 12.

These devices are useful for isolating high speed logic interfaces, buffering of input and output lines, and implementing isolated line receivers in high noise environments.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.5	20	Volts
Enable Voltage High	V_{EH}	2.0	20	Volts
Enable Voltage Low	V_{EL}	0	0.8	Volts
Input Current (High)	$I_{F\,(ON)}$	4	8	mA
Input Voltage (Low)	$V_{F\,(OFF)}$	0	0.8	Volts
Fan Out	N		4	TTL Loads

Absolute Maximum Ratings

Storage Temperature ..... -65° C to +150° C
Operating Temperature ..... -55° C to 125° C
Lead Solder Temperature ..... 260° C for 10 s
(1.6 mm below seating plane)
Average Forward Input Current — I_F ..... 8 mA
Peak Transient Input Current — I_{FPK} ..... 20 mA [1]
Reverse Input Voltage — V_R ..... 5 V
Supply Voltage — V_{CC} ..... 0.0 V min., 20 V max.
Three State Enable
Voltage — V_E ..... -0.3 V min., 20 V max.
Output Voltage — V_O ..... -0.3 V min., 20 V max.
Total Package Power Dissipation — P_d ..... 200 mW
Average Output Current — I_O ..... 15 mA

Electrical Characteristics

T_A = -55° C to 125° C, unless otherwise specified.
For 0 V ≤ $V_{F(OFF)}$ ≤ 0.8 V, 4.5 V ≤ V_{CC} ≤ 20 V, 4 mA ≤ $I_{F(ON)}$ ≤ 8 mA, 2.0 V ≤ V_{EH} ≤ 20 V, 0. V ≤ V_{EL} ≤ 0.8 V

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions		Fig.	Note
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 6.4 mA (4 TTL Loads)		1, 3	
Logic High Output Voltage	V_{OH}	2.4	**		Volts	I_{OH} = -2.6 mA	(**V_{OH} = V_{CC} - 2.1 V)	2, 3	
			3.1		Volts	I_{OH} = -0.32 mA			
Output Leakage Current (V_{OUT} > V_{CC})	I_{OHH}			100	µA	V_O = 5.5 V	I_F = 8 mA		
				500	µA	V_O = 20 V	V_{CC} = 4.5 V		
Logic High Enable Voltage	V_{EH}	2.0			Volts				
Logic Low Enable Voltage	V_{EL}			0.8	Volts				
Logic High Enable Curent	I_{EH}			20	µA	V_{EN} = 2.7 V			
				100	µA	V_{EN} = 5.5 V			
			0.004	250	µA	V_{EN} = 20 V			
Logic Low Enable Current	I_{EL}			-0.32	mA	V_{EN} = 0.4 V			
Logic Low Supply Current	I_{CCL}		4.5	6.0	mA	V_{CC} = 5.5 V	V_F = 0 V		
			5.3	7.5	mA	V_{CC} = 20 V	V_E = Don't Care		
Logic High Supply Current	I_{CCH}		2.9	4.5	mA	V_{CC} = 5.5 V	I_F = 8 mA,		
			3.3	6.0	mA	V_{CC} = 20 V	V_E = Don't Care		
High Impedance State Output Current	I_{OZL}			-20	µA	V_O = 0.4 V	V_{EN} = 2 V, V_F = 0 V		
	I_{OZH}			20	µA	V_O = 2.4 V	V_{EN} = 2 V, I_F = 8 mA		
				100	µA	V_O = 5.5 V			
				500	µA	V_O = 20 V			
Logic Low Short Circuit Output Current	I_{OSL}	20			mA	V_O = V_{CC} = 5.5 V	V_F = 0.8 V		2
		35			mA	V_O = V_{CC} = 20 V			
Logic High Short Circuit Output Current	I_{OSH}			-10	mA	V_{CC} = 5.5 V	I_F = 8 mA,		2
				-25	mA	V_{CC} = 20 V	V_O = GND		
Input Forward Voltage	V_F	1.0	1.3	1.8	Volts	I_F = 8 mA		4	
Input Reverse Breakdown Voltage	V_R	5			Volts	I_R = 10 µA			
Input-Output Insulation	I_{I-O}			1	µA	45% RH, t = 5s, V_{I-O} = 500 Vdc, T_A = 25° C			3, 4
Propagation Delay Time to Logic Low Output Level	t_{PHL}		100	300	ns			5, 6	5
Propagation Delay Time to Logic High Output Level	t_{PLH}		90	300	ns			5, 6	5
Logic High Common Mode Transient Immunity	$\|CM_H\|$	1000	10,000		V/µs	T_A = 25° C, I_F = 4 mA, V_{CM} = 50 V_{P-P}		9, 10	6
Logic Low Common Mode Transient Immunity	$\|CM_L\|$	1000	10,000		V/µs	T_A = 25° C, I_F = 0 mA, V_{CM} = 50 V_{P-P}		9, 10	6

*All typical values are at T_A = 25° C, V_{CC} = 5 V, $I_{F(ON)}$ = 5 mA unless otherwise specified.

Typical Characteristics

All typical values are at V_{CC} = 5 V, T_A = 25° C, $I_{F(ON)}$ = 5 mA unless otherwise specified.

Parameter	Symbol	Typ.	Units	Test Conditions	Figure	Note
Input Current Hysteresis	I_{HYS}	0.07	mA	V_{CC} = 5 V	3	
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$	-1.25	mV/°C	I_F = 8 mA		
Input-Output Resistance	R_{I-O}	10^{12}	ohms	V_{I-O} = 500 V dc		4,7
Input-Output Capacitance	C_{I-O}	2.0	pF	f = 1 MHz		7
Input Capacitance	C_{IN}	15	pF	f = 1 MHz, V_F = 0 V		8
Output Enable Time to Logic High	t_{PZH}	30	ns		7	
Output Enable Time to Logic Low	t_{PZL}	30	ns		7	
Output Disable Time from Logic High	t_{PHZ}	45	ns		7	
Output Disable Time from Logic Low	t_{PLZ}	55	ns		7	
Output Rise Time (10-90%)	t_r	45	ns		5, 8	
Output Fall Time (90-10%)	t_f	10	ns		5, 8	

Notes:

1. Peak Forward Input Current pulse width < 50 μs at 1 KHz maximum repetition rate.
2. Duration of output short circuit time not to exceed 10 ms.
3. Device considered a two terminal device: pins 1, 2, 3 and 4 shorted together, and pins 5, 6, 7 and 8 shorted together.
4. This is a momentary withstand test, not an operating condition.
5. The t_{PLH} propagation delay is measured from the 50% point on the leading edge of the input pulse to the 1.3 V point on the leading edge of the output pulse. The t_{PHL} propagation delay is measured from the 50% point on the trailing edge of the input current pulse to the 1.3 V point on the trailing edge of the output pulse.
6. CM_L is the maximum rate of rise of the common mode voltage that can be sustained with the output voltage in the logic low state (V_O < 0.8 V). CM_H is the maximum rate of fall of the common mode voltage that can be sustained with the output voltage in the logic high state (V_O > 2.0 V).
7. Measured between the LED anode and cathode shorted together and pins 5 through 8 shorted together.
8. Zero bias capacitance measured between the LED anode and cathode.

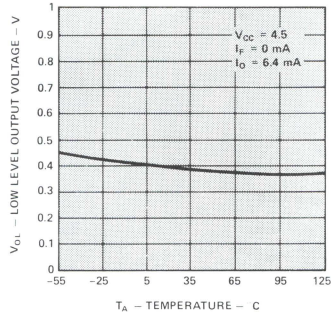


Figure 1. Typical Logic Low Output Voltage vs. Temperature

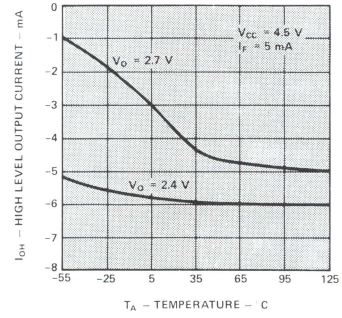


Figure 2. Typical Logic High Output Current vs. Temperature

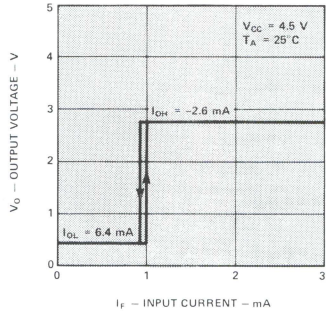


Figure 3. Output Voltage vs. Forward Input Current

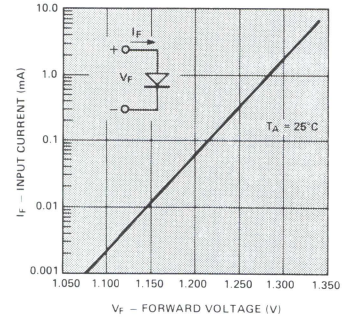


Figure 4. Typical Input Diode Forward Characteristic

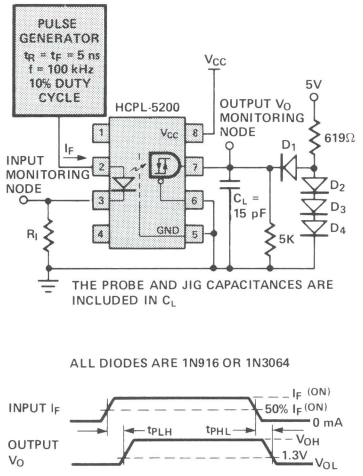
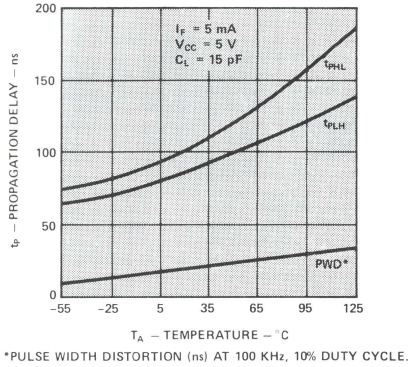


Figure 5. Test Circuit for t_{PLH}, t_{PHL}, t_r, and t_f



*PULSE WIDTH DISTORTION (ns) AT 100 KHz, 10% DUTY CYCLE.

Figure 6. Typical Propagation Delay vs. Temperature

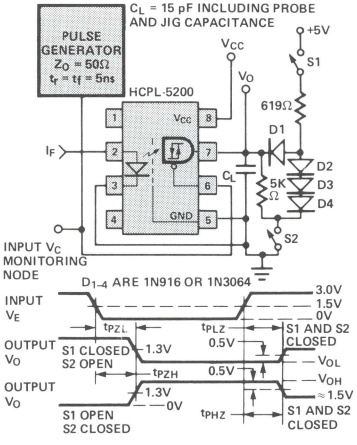


Figure 7. Test Circuit for t_{PHZ}, t_{PZH}, t_{PLZ}, and t_{PZL}

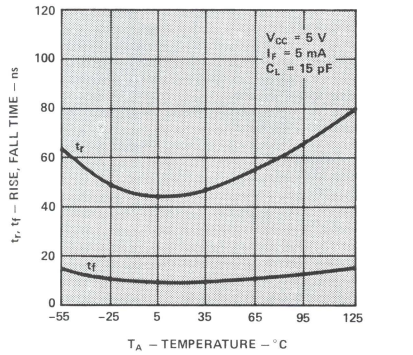
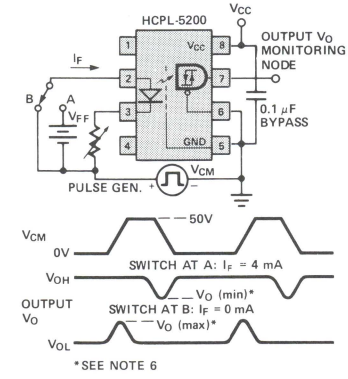


Figure 8. Typical Rise, Fall Time vs. Temperature



*SEE NOTE 6

Figure 9. Test Circuit for Common Mode Transient Immunity and Typical Waveforms

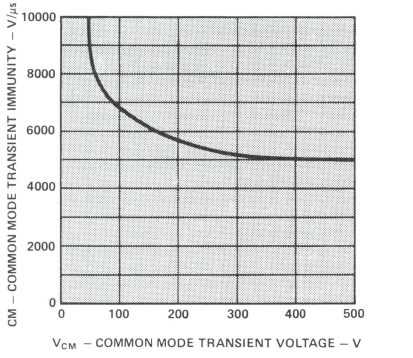


Figure 10. Typical Common Mode Transient Immunity vs. Common Mode Transient Amplitude

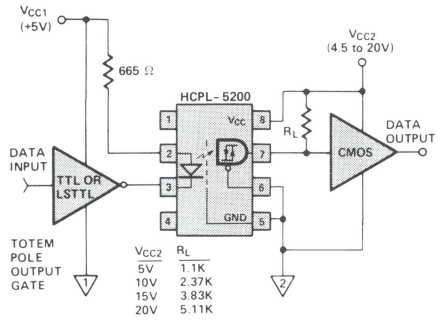


Figure 11. LSTTL to CMOS Interface Circuit

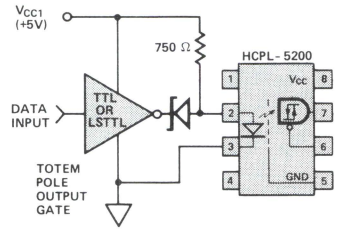


Figure 12. Recommended LED Drive Circuit

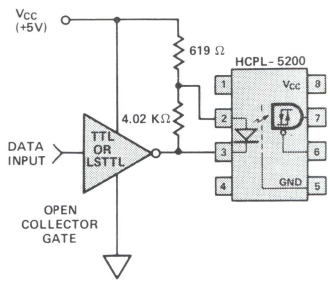


Figure 13. Series LED Drive with Open Collector Gate (4.02 KΩ Resistor Shunts I_{OH} from the LED)

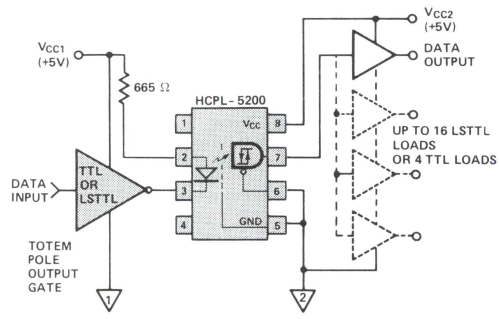


Figure 14. Recommended LSTTL to LSTTL Circuit

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's HCPL-5201 optocoupler is in compliance with MIL-STD-883, Revision C. Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

See table for specific electrical tests, pg. 6.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
HCPL-5200	HCPL-5201

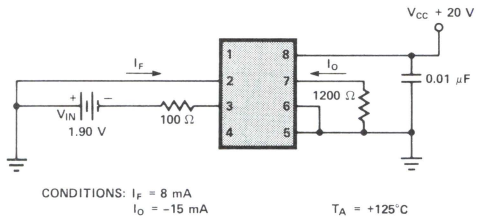


Figure 15. Operating Circuit for Burn-In and Steady State Life Tests

GROUP A — ELECTRICAL TESTS

QUANTITY/ACCEPT NO. = 116/0

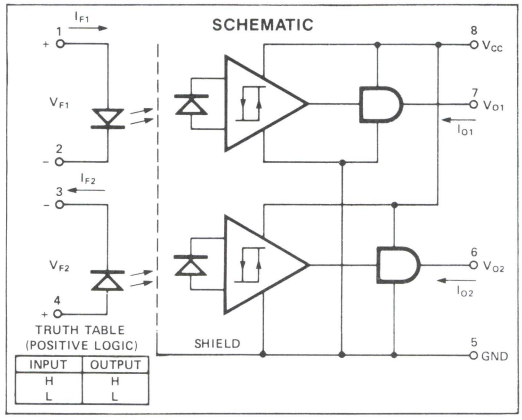
Subgroup 1 *Static tests at T_A = 25°C — V_F, V_R, I_{I-O}, I_{OHH}, V_{OH}, V_{OL}, I_{CCH}, I_{CCL}, I_{OZL}, I_{EH}, I_{EL}, V_{EL}, V_{EH}, I_{OSL}, I_{OSH}
Subgroup 2 *Static tests at T_A = +125°C — V_F, V_R, I_{OHH}, V_{OH}, V_{OL}, I_{CCH}, I_{CCL}, I_{OZL}, I_{EH}, I_{EL}, V_{EL}, V_{EH}, I_{OSL}, I_{OSH}
Subgroup 3 *Static tests at T_A = -55°C — V_F, V_R, I_{OHH}, V_{OH}, V_{OL}, I_{CCH}, I_{CCL}, I_{OZL}, I_{EH}, I_{EL}, V_{EL}, V_{EH}, I_{OSL}, I_{OSH}
Subgroup 4, 5, 6, 7, 8A and 8B These subgroups are not applicable to this device type.
Subgroup 9 *Switching tests at T_A = 25°C — t_{PHL}, t_{PLH}, $\|CM_H\|$, $\|CM_L\|$
Subgroup 10 *Switching tests at T_A = +125°C — t_{PHL}, t_{PLH}
Subgroup 11 *Switch tests at T_A = -55°C — t_{PHL}, t_{PLH}

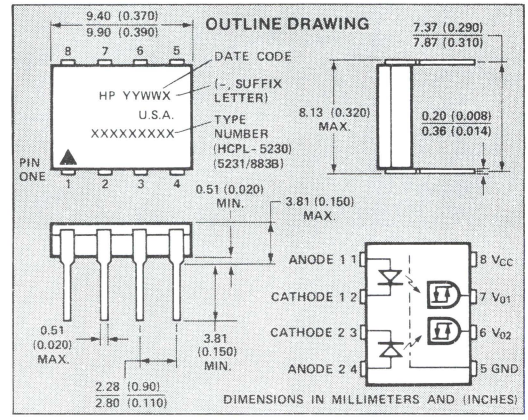
*Limits and conditions per Electrical Characteristics.

HEWLETT PACKARD

DUAL CHANNEL WIDE SUPPLY VOLTAGE, HIGH CMR, HERMETICALLY SEALED OPTOCOUPLER

HCPL-5230
HCPL-5231
(883B)





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- HERMETICALLY SEALED 8 PIN DUAL IN-LINE PACKAGE
- PERFORMANCE GUARANTEED OVER -55° C TO +125° C AMBIENT TEMPERATURE RANGE
- WIDE V_{CC} RANGE (4.5 TO 20 VOLTS)
- MIL-STD-883 CLASS B TESTING
- 500 Vdc WITHSTAND TEST VOLTAGE
- COMPATIBLE WITH LSTTL, TTL, AND CMOS LOGIC
- 300 ns PROPAGATION DELAY GUARANTEED OVER TEMPERATURE
- HCPL-2231 FUNCTION COMPATIBILITY
- TOTEM POLE OUTPUT (NO PULL-UP RESISTOR REQUIRED)
- NO OPTICAL CROSSTALK
- INTERNAL SHIELD FOR HIGH COMMON MODE REJECTION — 1000 V/μs GUARANTEED

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- ISOLATION OF HIGH SPEED LOGIC SYSTEMS
- COMPUTER-PERIPHERAL INTERFACES
- MICROPROCESSOR SYSTEM INTERFACES
- PULSE TRANSFORMER REPLACEMENT
- ISOLATED BUS DRIVER
- HIGH SPEED LINE RECEIVER

Description

The HCPL-5230 and 5231 units are dual channel, hermetically sealed, logic gate optocouplers. The products are capable of operation and storage over the full military temperature range and can be purchased as either a standard product (HCPL-5230) or with full MIL-STD-883 Class Level B testing (HCPL-5231). Both products are in eight pin hermetic dual in-line packages.

Each unit contains two independent channels, consisting of an AlGaAs light emitting diode optically coupled to an integrated high gain photon detector. The detector has a totem pole output and a threshold with hysteresis. The hysteresis provides differential mode noise immunity and eliminates the potential for output signal chatter. The detector IC has an internal shield that provides a guaranteed common mode transient immunity of 1,000 volts/μsec. Improved power supply rejection eliminates the need for special power supply bypassing precautions.

The HCPL-5230 and HCPL-5231 are guaranteed to operate over a V_{CC} range of 4.5 Volts to 20 Volts. Low I_F and wide V_{CC} range allow compatibiiity with TTL, LSTTL, and CMOS logic. Low I_F and low I_{CC} result in lower power consumption compared to other high speed optocouplers. Logic signals are transmitted with a typical propagation delay of 100 nsec when used in the circuit of Figure 11.

These devices are useful for isolating high speed logic interfaces, buffering of input and output lines, and implementing isolated line receivers in high noise environments.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.5	20	Volts
Input Current (High)	$I_{F\ (ON)}$	4	8	mA
Input Voltage (Low)	$V_{F\ (OFF)}$	0	0.8	Volts
Fan Out	N		4	TTL Loads

Absolute Maximum Ratings

Storage Temperature ..... -65°C to +150°C
Operating Temperature ..... -55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 s
(1.6 mm below seating plane)
Average Forward Input Current — I_F ..... 8 mA
Peak Transient Input Current — I_{FPK} ..... 20 mA[1]
Reverse Input Voltage ..... 5 V
Supply Voltage — V_{CC} ..... 0.0 V min., 20 V max.
Output Voltage — V_O ..... -0.3 V min., 20 V max.
Total Package Power Dissipation — P_d ..... 400 mW
Average Output Current — I_O(per channel) ..... 15 mA

Electrical Characteristics

T_A = -55°C to 125°C, unless otherwise specified.
For 4.5 V ≤ V_{CC} ≤ 20 V, 4 mA ≤ $I_{F(ON)}$ ≤ 8 mA, 0 V ≤ $V_{F(OFF)}$ ≤ 0.8 V

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions		Fig.	Note
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 6.4 mA (4 TTL Loads)		1,3	2
Logic High Output Voltage	V_{OH}	2.4	**		Volts	I_{OH} = -2.6 mA	(**V_{OH} = V_{CC}-2.1 V)	2,3	2
			3.1		Volts	I_{OH} = -0.32 mA			
Output Leakage Current (V_{OUT} > V_{CC})	I_{OHH}			100	μA	V_O = 5.5 V	I_F = 8 mA V_{CC} = 4.5 V		2
				500	μA	V_O = 20 V			
Logic Low Supply Current	I_{CCL}		9.0	12.0	mA	V_{CC} = 5.5 V	V_{F1} = V_{F2} = 0 V		
			10.6	15	mA	V_{CC} = 20 V			
Logic High Supply Current	I_{CCH}		5.8	9.0	mA	V_{CC} = 5.5 V	I_{F1} = I_{F2} = 8 mA		
			6.6	12.0	mA	V_{CC} = 20 V			
Logic Low Short Circuit Output Current	I_{OSL}	20			mA	V_O = V_{CC} = 5.5 V	V_F = 0 V		2,3
		35			mA	V_O = V_{CC} = 20 V			
Logic High Short Circuit Output Current	I_{OSH}	-10			mA	V_{CC} = 5.5 V	I_F = 8 mA, V_O = GND		2,3
		-25			mA	V_{CC} = 20 V			
Input Forward Voltage	V_F	1.0	1.3	1.8	Volts	I_F = 8 mA		4	2
Input Reverse Breakdown Voltage	V_R	5			Volts	I_R = 10 μA			2
Input-Output Insulation	I_{I-O}			1	μA	45% RH, t = 5s, V_{I-O} = 500 Vdc, T_A = 25°C			4,5
Propagation Delay Time to Logic Low Output Level	t_{PHL}		100	300	ns			5, 6	2,6
Propagation Delay Time to Logic High Output Level	t_{PLH}		90	300	ns			5, 6	2,6
Logic High Common Mode Transient Immunity	$\|CM_H\|$	1000	10,000		V/μs	T_A = 25°C, I_F = 4 mA V_{CM} = 50 V_{P-P}		8, 9	2,7
Logic Low Common Mode Transient Immunity	$\|CM_L\|$	1000	10,000		V/μs	T_A = 25°C, I_F = 0 mA V_{CM} = 50 V_{P-P}		8, 9	2,7

*All typical values are at T_A = 25°C, V_{CC} = 5 V, $I_{F\ (ON)}$ = 5 mA unless otherwise specified.

Notes:

1. Peak Forward Input Current pulse width < 50 μs at 1 KHz maximum repetition rate.
2. Each channel.
3. Duration of output short circuit time not to exceed 10 ms.
4. Device considered a two-terminal device: Pins 1 through 4 are shorted together, and pins 5 through 8 are shorted together.
5. This is a momentary withstand test, not an operating condition.
6. t_{PHL} propagation delay is measured from the 50% point on the leading edge of the input pulse to the 1.3 V point on the leading edge of the output pulse. The t_{PLH} propagation delay is measured from the 50% point on the trailing edge of the input pulse to the 1.3 V point on the trailing edge of the output pulse.
7. CM_L is the maximum rate of rise of the common mode voltage that can be sustained with the output voltage in the logic low state (V_O < 0.8 V). CM_H is the maximum rate of fall of the common mode voltage that can be sustained with the output voltage in the logic high state (V_O > 2.0 V).
8. Measured between the LED anode and cathode shorted together and pins 5 through 8 shorted together.
9. Measured between adjacent input pairs shorted together, i.e. between pins 1 and 2 shorted together and pins 3 and 4 shorted together.
10. Zero-bias capacitance measured between the LED anode and cathode.

Typical Characteristics

All typical values are at V_{CC} = 5 V, T_A = 25°C, $I_{F\,(ON)}$ = 5 mA unless otherwise specified.

Parameter	Symbol	Typ.	Units	Test Conditions	Fig.	Note
Input Current Hysteresis	I_{HYS}	0.07	mA	V_{CC} = 5 V	3	2
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$	-1.25	mV/°C	I_F = 8 mA		2
Input-Output Resistance	R_{I-O}	10^{12}	ohms	V_{I-O} = 500 Vdc		2,8
Input-Output Capacitance	C_{I-O}	2.0	pF	f = 1 MHz		2,8
Input-Input Insulation Leakage Current	I_{I-I}	0.5	nA	45% Relative Humidity, V_{I-I} = 500 Vdc, T_A = 25°C, t = 5 s		9
Resistance (Input-Input)	R_{I-I}	10^{12}	Ω	V_{I-I} = 500 Vdc		9
Capacitance (Input-Input)	C_{I-I}	1.3	pF	f = 1 MHz		9
Input Capacitance	C_{IN}	15	pF	f = 1 MHz, V_F = 0 V		2,10
Output Rise Time (10-90%)	t_r	45	ns		5, 7	2
Output Fall Time (90-10%)	t_f	10	ns		5, 7	2

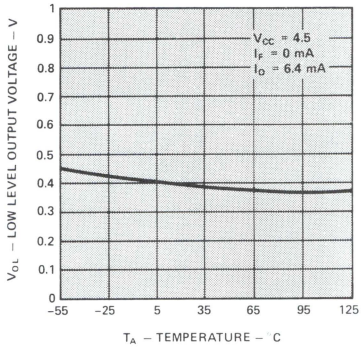


Figure 1. Typical Logic Low Output Voltage vs. Temperature

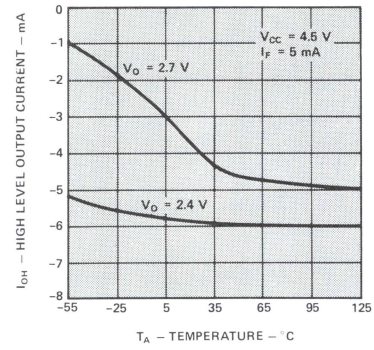


Figure 2. Typical Logic High Output Current vs. Temperature

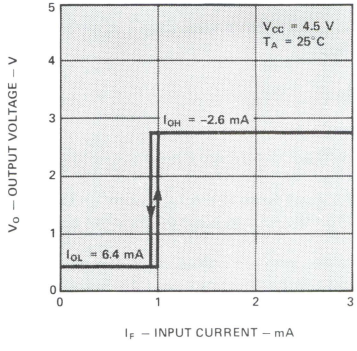


Figure 3. Output Voltage vs. Forward Input Current

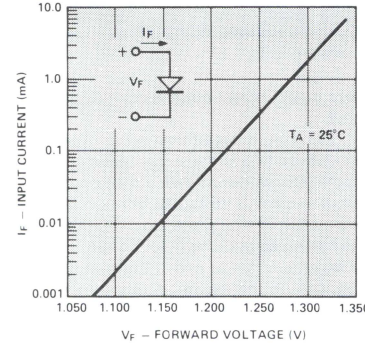


Figure 4. Typical Diode Input Forward Characteristic

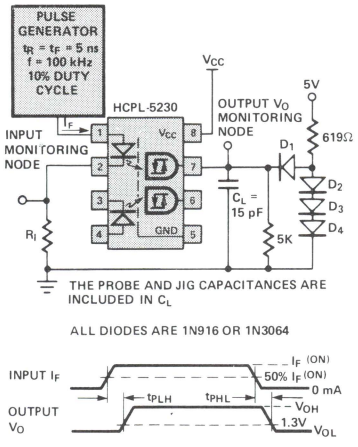
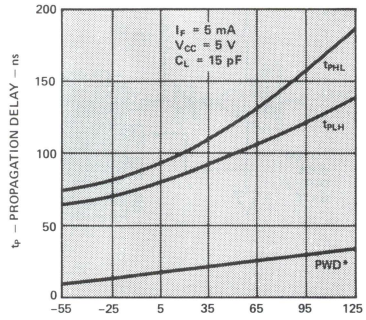


Figure 5. Test Circuit for t_{PLH}, t_{PHL}, t_r, and t_f



*PULSE WIDTH DISTORTION (ns) AT 100 KHz, 10% DUTY CYCLE.

Figure 6. Typical Propagation Delay vs. Temperature

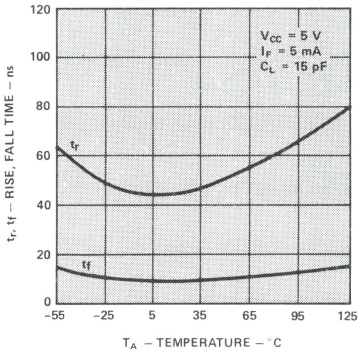
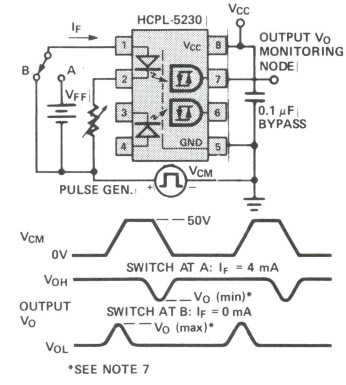


Figure 7. Typical Rise, Fall Time vs. Temperature



*SEE NOTE 7

Figure 8. Test Circuit for Common Mode Transient Immunity and Typical Waveforms

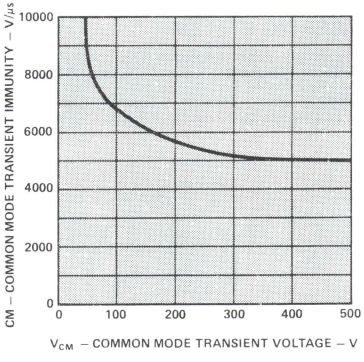


Figure 9. Typical Common Mode Transient Immunity vs. Common Mode Transient Amplitude

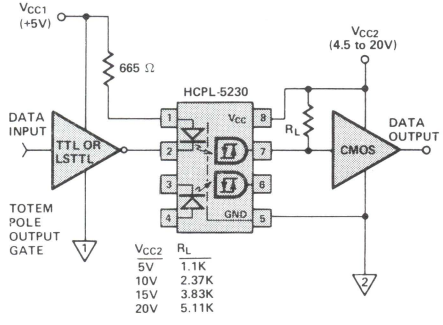


Figure 10. LSTTL to CMOS Interface Circuit

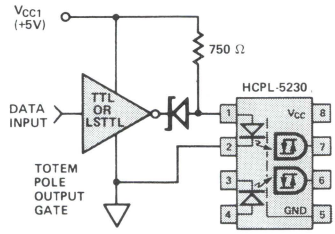


Figure 11. Recommended LED Drive Circuit

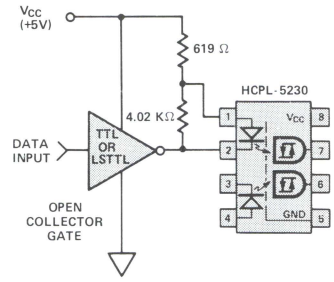


Figure 12. Series LED Drive with Open Collector Gate (4.02 KΩ Resistor Shunts I_{OH} from the LED)

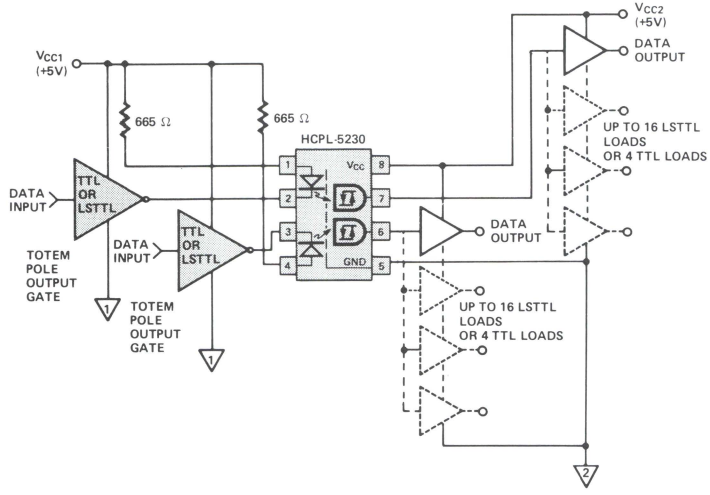


Figure 13. Recommended LSTTL to LSTTL Circuit

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's HCPL-5231 optocoupler is in compliance with MIL-STD-883, Revision C. Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

See table on next page for specific electrical tests.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
HCPL-5230	HCPL-5231

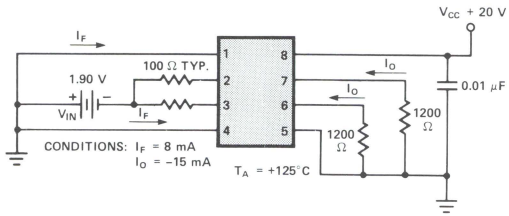


Figure 14. Operating Circuit for Burn-In and Steady State Life Tests

GROUP A — ELECTRICAL TESTS

QUANTITY/ACCEPT NO. = 116/0

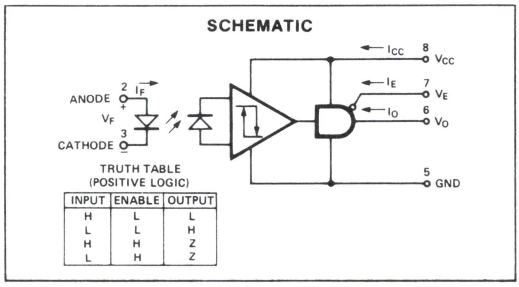
Subgroup 1 *Static tests at T_A = 25°C — V_F, V_R, I_{I-O}, I_{OHH}, V_{OH}, V_{OL}, I_{CCH}, I_{CCL}, I_{OSL}, I_{OSH}
Subgroup 2 *Static tests at T_A = +125°C — V_F, V_R, I_{OHH}, V_{OH}, V_{OL}, I_{CCH}, I_{CCL}, I_{OSL}, I_{OSH}
Subgroup 3 *Static tests at T_A = -55°C — V_F, V_R, I_{OHH}, V_{OH}, V_{OL}, I_{CCH}, I_{CCL}, I_{OSL}, I_{OSH}
Subgroup 4, 5, 6, 7, 8A and 8B These subgroups are not applicable to this device type.
Subgroup 9 *Switching tests at T_A = 25°C — t_{PHL}, t_{PLH}, $\|CM_H\|$, $\|CM_L\|$
Subgroup 10 *Switching tests at T_A = +125°C — t_{PHL}, t_{PLH}
Subgroup 11 *Switch tests at T_A = -55°C — t_{PHL}, t_{PLH}

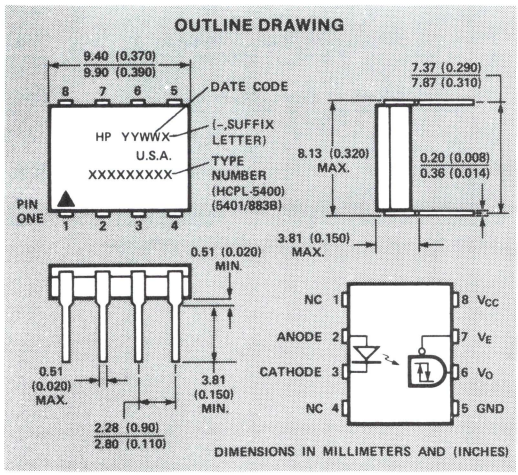
*Limits and conditions per Electrical Characteristics.

HEWLETT PACKARD

HIGH SPEED, HERMETICALLY SEALED OPTOCOUPLER

HCPL-5400
HCPL-5401
(883B)





Features

- **NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE**
- **HERMETICALLY SEALED 8 PIN DUAL IN-LINE PACKAGE**
- **PERFORMANCE GUARANTEED OVER -55°C TO +125°C AMBIENT TEMPERATURE RANGE**
- **MIL-STD-883 CLASS B TESTING**
- **HIGH SPEED GUARANTEED OVER TEMPERATURE**
- **75 ns MAXIMUM PROPAGATION DELAY**
- **35 ns MAXIMUM PULSE WIDTH DISTORTION**
- **HIGH COMMON MODE REJECTION — 500 V/μs GUARANTEED**
- **HCPL-2400 FUNCTION COMPATIBILITY**
- **COMPATIBLE WITH TTL, STTL, LSTTL, AND HCMOS LOGIC FAMILIES**
- **THREE STATE OUTPUT (NO PULL-UP RESISTOR REQUIRED)**
- **HIGH POWER SUPPLY NOISE IMMUNITY**
- **500 Vdc WITHSTAND TEST VOLTAGE**

Applications

- **MILITARY/HIGH RELIABILITY SYSTEMS**
- **ISOLATION OF HIGH SPEED LOGIC SYSTEMS**
- **COMPUTER-PERIPHERAL INTERFACES**
- **ISOLATED BUS DRIVER (NETWORKING APPLICATIONS)**
- **SWITCHING POWER SUPPLIES**
- **GROUND LOOP ELIMINATION**
- **HIGH SPEED DISK DRIVE I/O**
- **DIGITAL ISOLATION FOR A/D, D/A CONVERSION**
- **PULSE TRANSFORMER REPLACEMENT**

Description

The HCPL-5400 and HCPL-5401 units are hermetically sealed, high speed optocouplers. The products are capable of operation and storage over the full military temperature range and can be purchased as either a standard product (HCPL-5400) or with full MIL-STD-883 Class Level B testing (HCPL-5401). Both products are in eight pin hermetic dual in-line packages.

Each unit contains an AlGaAs light emitting diode which is optically coupled to an integrated high speed photon detector. This combination results in very high data rate capability. The detector has a threshold with hysteresis and a three state output stage. The three state output eliminates the need for a pull-up resistor and allows for direct drive of a data bus. The hysteresis provides typically 0.25 mA of differential mode noise immunity and minimizes the potential for output signal chatter.

The HCPL-5400 and HCPL-5401 are compatible with TTL, STTL, LSTTL, and HCMOS logic families. The 35 ns pulse width distortion specification guarantees a 10 mBaud signaling rate at 125°C with 35% pulse width distortion. Figure 11 shows a recommended circuit for reducing pulse width distortion and improving the signaling rate of the product.

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.75	5.25	Volts
Input Current (High)	$I_{F(ON)}$	8	10	mA
Input Voltage (Low)	$V_{F(OFF)}$	—	0.7	Volts
Enable Voltage (Low)	V_{EL}	0	0.8	Volts
Enable Voltage (High)	V_{EH}	2.0	V_{CC}	Volts
Fan Out	N		5	TTL Loads

Absolute Maximum Ratings

Storage Temperature ..... -65°C to +150°C
Operating Temperature ..... -55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 s
(1.6 mm below seating plane)
Average Forward Current — $I_{F\,AVG}$ ..... 10 mA
Peak Input Current — $I_{F\,PK}$ ..... 20 mA[1]
Reverse Input Voltage — V_R ..... 5 V
Supply Voltage — V_{CC} ..... 0 V min., 7.0 V max.
Three State Enable Voltage — V_E .... -0.5 V min., 10 V max.
Average Output Current — I_O .... -25 mA min., 25 mA max.
Output Voltage — V_O ..... -0.5 V min., 10 V max.
Output Power Dissipation — P_O ..... 130 mW
Total Package Power Dissipation P_d ..... 400 mW

Electrical Characteristics

T_A = -55°C to 125°C, 4.75 V ≤ V_{CC} ≤ 5.25 V, 8 mA ≤ $I_{F(ON)}$ ≤ 10 mA, 2.0 V ≤ V_{EH} ≤ 5.25, 0 V ≤ V_{EL} ≤ 0.8 V, 0 V ≤ $V_{F(OFF)}$ ≤ 0.7 V, unless otherwise specified.

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions	Figure	Note
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 8.0 mA (5 TTL Loads)	1	
Logic High Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -4.0 mA	2	
Output Leakage Current	I_{OHH}			100	μA	V_O = 5.25 V, V_F = 0.7 V		
Logic High Enable Voltage	V_{EH}	2.0			Volts			
Logic Low Enable Voltage	V_{EL}			0.8	Volts			
Logic High Enable Current	I_{EH}			20	μA	V_E = 2.4 V		
				100	μA	V_E = 5.25 V		
Logic Low Enable Current	I_{EL}		-0.28	-0.4	mA	V_E = 0.4 V		
Logic Low Supply Current	I_{CCL}		19	26	mA	V_{CC} = 5.25 V		
Logic High Supply Current	I_{CCH}		17	26	mA	V_E = 0 V		
High Impedance State Supply Current	I_{CCZ}		22	28	mA	V_{CC} = 5.25 V V_E = 5.25 V		
High Impedance State Output Current	I_{OZL}			20	μA	V_O = 0.4 V, V_E = 2 V		
	I_{OZH}			20	μA	V_O = 2.4 V, V_E = 2 V		
				100	μA	V_O = 5.25 V		
Input Forward Voltage	V_F	1.0	1.4	1.85	Volts	I_F = 10 mA	4	
Input Reverse Breakdown Voltage	V_R	5.0	7.0		Volts	I_R = 10 μA		
Input-Output Insulation Leakage Current	I_{I-O}			1	μA	45% RH, t = 5 s, V_{I-O} = 500 Vdc, T_A = 25°C		2, 3
Propagation Delay Time to Logic Low Output Level	t_{PHL}		33	75	ns	$I_{F(ON)}$ = 9 mA	5, 6, 7	4
Propagation Delay Time to Logic High Output Level	t_{PLH}		30	65	ns	$I_{F(ON)}$ = 9 mA	5, 6, 7	4
Pulse Width Distortion	$\lvert t_{PHL}-t_{PLH}\rvert$		3	35	ns	$I_{F(ON)}$ = 9 mA	5, 6	
Logic High Common Mode Transient Immunity	$\lvert CM_H\rvert$	500	3000		V/μs	T_A = 25°C, I_F = 0	10	5
Logic Low Common Mode Transient Immunity	$\lvert CM_L\rvert$	500	3000		V/μs	T_A = 25°C, I_F = 8 mA	10	5

*All typical values are at V_{CC} = 5 V, T_A = 25°C

Typical Characteristics

All typicals V_{CC} = 5 V, V_E = 0 V, T_A = 25°C, I_F = 9 mA except where noted.

Parameter	Symbol	Typ.	Units	Test Conditions	Figure	Note
Input Current Hysteresis	I_{HYS}	0.25	mA		3	
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$	-1.11	mV/°C	I_F = 10 mA	4	
Input-Output Resistance	R_{I-O}	10^{12}	ohms	V_{I-O} = 500 VDC		2
Input-Output Capacitance	C_{I-O}	0.6	pF	f = 1 MHz, V_{I-O} = 0 Vdc		2
Input Capacitance	C_{IN}	15	pF	f = 1 MHz, V_F = 0 V, Pins 2 and 3		
Logic Low Short Circuit Output Current	I_{OSL}	65	mA	V_O = V_{CC} = 5.25 V, I_F = 10 mA		6
Logic High Short Circuit Output Current	I_{OSH}	-50	mA	V_{CC} = 5.25 V, I_F = 0 mA, V_O = GND		6
Output Rise Time (10-90%)	t_r	15	ns		5	
Output Fall Time (90-10%)	t_f	10	ns		5	
Output Enable Time to Logic High	t_{PZH}	15	ns		8, 9	
Output Enable Time to Logic Low	t_{PZL}	30	ns		8, 9	
Output Disable Time from Logic High	t_{PHZ}	20	ns		8, 9	
Output Disable Time from Logic Low	t_{PLZ}	15	ns		8, 9	
Power Supply Noise Immunity	PSNI	0.5	V_{p-p}	48 Hz ≤ f_{AC} ≤ 50 MHz		7

Notes:

1. Not to exceed 5% duty factor, not to exceed 50 μsec pulse width.
2. Device considered a two terminal device: pin 1-4 shorted together, and pins 5-8 shorted together.
3. This is a momentary withstand test, not an operating condition.
4. t_{PHL} propagation delay is measured from the 50% level on the rising edge of the input current pulse to the 1.5 V level on the falling edge of the output pulse. The t_{PLH} propagation delay is measured from the 50% level on the falling edge of the input current pulse to the 1.5 V level on the rising edge of the output pulse.
5. CM_H is the maximum slew rate of common mode voltage that can be sustained with the output voltage in the logic high state ($V_{O\,(MIN)}$ > 2.0). CM_L is the maximum slew rate of common mode voltage that can be sustained with the output voltage in the logic low state ($V_{O\,(MAX)}$ < 0.8 V).
6. Duration of output short circuit time not to exceed 10 ms.
7. Power Supply Noise Immunity is the peak to peak amplitude of the ac ripple voltage on the V_{CC} line that the device will withstand and still remain in the desired logic state. For desired logic high state, $V_{OH\,(MIN)}$ > 2.0 V, and for desired logic low state, $V_{OL\,(MAX)}$ < 0.8 volts.

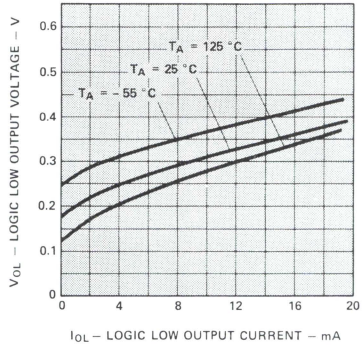


Figure 1. Typical Logic Low Output Voltage vs. Logic Low Output Current

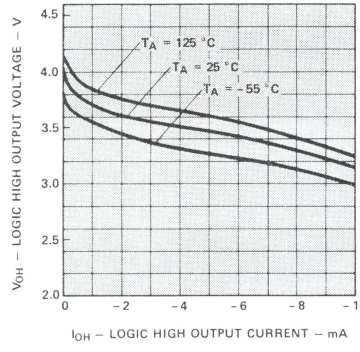


Figure 2. Typical Logic High Output Voltage vs. Logic High Output Current

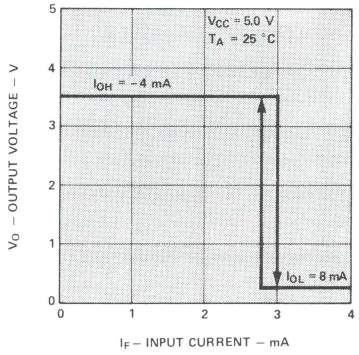


Figure 3. Typical Output Voltage vs. Input Forward Current

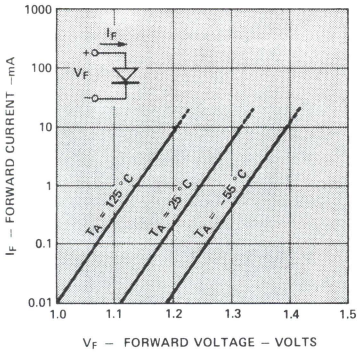


Figure 4. Typical Diode Input Forward Current Characteristic

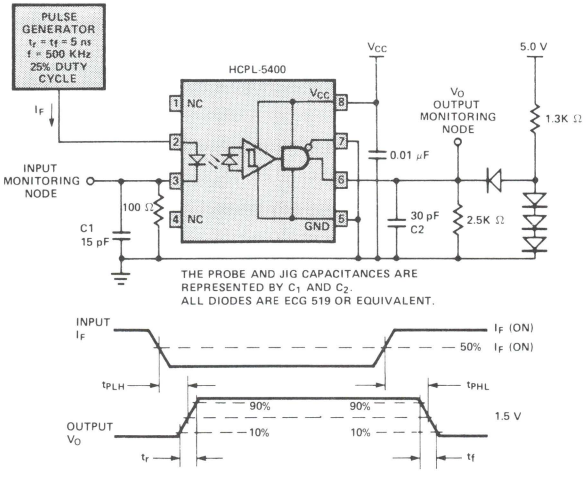


Figure 5. Test Circuit for t_{PLH}, t_{PHL}, t_r, and t_f

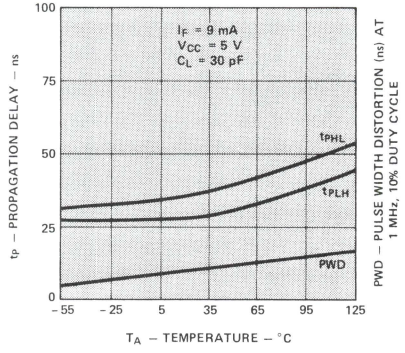


Figure 6. Typical Propagation Delay vs. Ambient Temperature

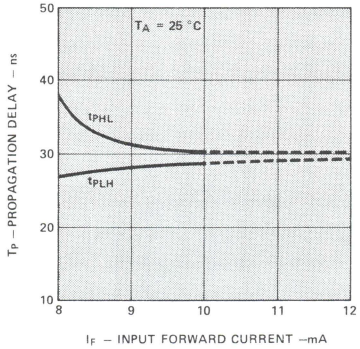
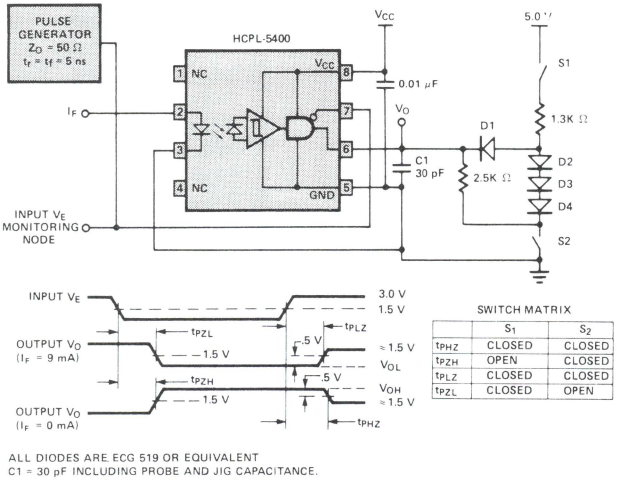


Figure 7. Typical Propagation Delay vs. Input Forward Current



	S_1	S_2
t_{PHZ}	CLOSED	CLOSED
t_{PZH}	OPEN	CLOSED
t_{PLZ}	CLOSED	CLOSED
t_{PZL}	CLOSED	OPEN

Figure 8. Test Circuit for t_{PHZ}, t_{PZH}, t_{PLZ}, and t_{PZL}

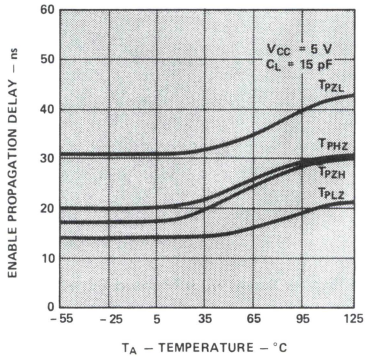
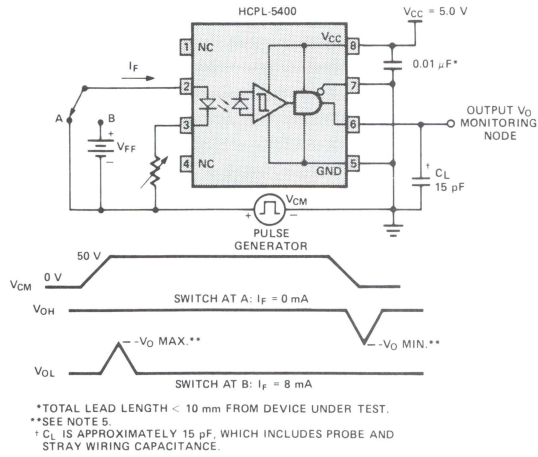


Figure 9. Typical Enable Propagation Delay vs. Ambient Temperature



*TOTAL LEAD LENGTH < 10 mm FROM DEVICE UNDER TEST.
**SEE NOTE 5.
† C_L IS APPROXIMATELY 15 pF, WHICH INCLUDES PROBE AND STRAY WIRING CAPACITANCE.

Figure 10. Test Diagram for Common Mode Transient Immunity and Typical Waveforms

Applications

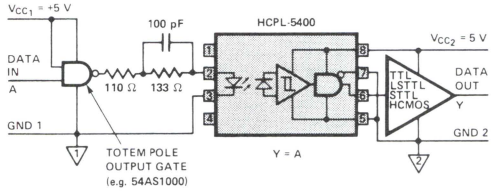


Figure 11. Recommended HCPL-5400 Interface Circuit

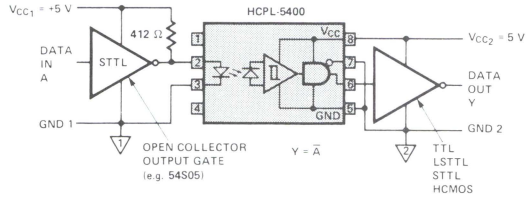


Figure 12. Alternative HCPL-5400 Interface Circuit

Data Rate, and Pulse-Width Distortion Definitions

Propagation delay is a figure of merit which describes the finite amount of time required for a system to translate information from input to output when shifting logic levels. Propagation delay from low to high (t_{PLH}) specifies the amount of time required for a system's output to change from a Logic 0 to a Logic 1, when given a stimulus at the input. Propagation delay from high to low (t_{PHL}) specifies the amount of time required for a system's output to change from a Logic 1 to a Logic 0, when given a stimulus at the input (see Figure 5).

When t_{PLH} and t_{PHL} differ in value, pulse width distortion results. Pulse width distortion is defined as $|t_{PHL}-t_{PLH}|$ and determines the maximum data rate capability of a distortion-limited system. Maximum pulse width distortion on the order of 25-35% is typically used when specifying the maximum data rate capabilities of systems. The exact figure depends on the particular application (RS-232, PCM, T-1, etc.).

The HCPL-5400 optocoupler offers the advantages of specified propagation delay (t_{PLH}, t_{PHL}), and pulse-width distortion ($|t_{PLH}-t_{PHL}|$) over temperature, and power supply voltage ranges.

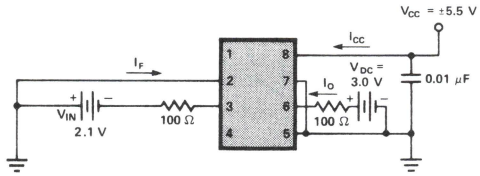
MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's HCPL-5401 optocoupler is in compliance with MIL-STD-883, Revision C. Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

See table below for specific electrical tests.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
HCPL-5400	HCPL-5401



CONDITIONS:
I_F = 10 mA, I_{CC} = 25 mA,
I_O = 25 mA, T_A = +125°C

Figure 13. Operating Circuit for Burn-In and Steady State Life Tests

GROUP A — ELECTRICAL TESTS

QUANTITY/ACCEPT NO. = 116/0

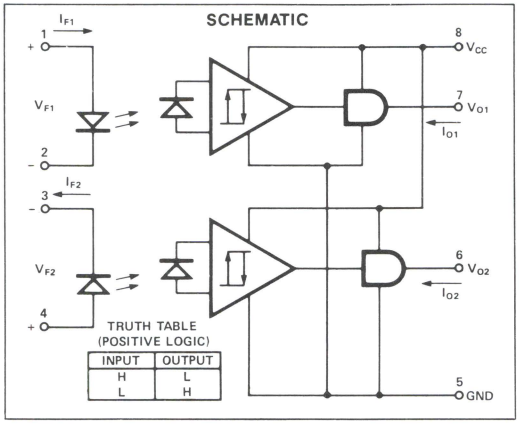
Subgroup 1 *Static tests at T_A = 25°C — V_{OL}, V_{OH}, I_{OHH}, V_{EH}, V_{EL}, I_{EH}, I_{EL}, I_{CCL}, I_{CCH}, I_{CCZ}, I_{OZL}, I_{OZH}, V_F, V_R, I_{I-O}
Subgroup 2 *Static tests at T_A = +125°C — V_{OL}, V_{OH}, I_{OHH}, V_{EH}, V_{EL}, I_{EH}, I_{EL}, I_{CCL}, I_{CCH}, I_{CCZ}, I_{OZL}, I_{OZH}, V_F, V_R
Subgroup 3 *Static tests at T_A = -55°C — V_{OL}, V_{OH}, I_{OHH}, V_{EH}, V_{EL}, I_{EH}, I_{EL}, I_{CCL}, I_{CCH}, I_{CCZ}, I_{OZL}, I_{OZH}, V_F, V_R
Subgroup 4, 5, 6, 7, 8A and 8B These subgroups are not applicable to this device type.
Subgroup 9 *Switching tests at T_A = 25°C — t_{PHL}, t_{PLH}, $\|t_{PHL}-t_{PLH}\|$, $\|CM_H\|$, $\|CM_L\|$
Subgroup 10 *Switching tests at T_A = +125°C — t_{PHL}, t_{PLH}, $\|t_{PHL}-t_{PLH}\|$
Subgroup 11 *Switching tests at T_A = -55°C — t_{PHL}, t_{PLH}, $\|t_{PHL}-t_{PLH}\|$

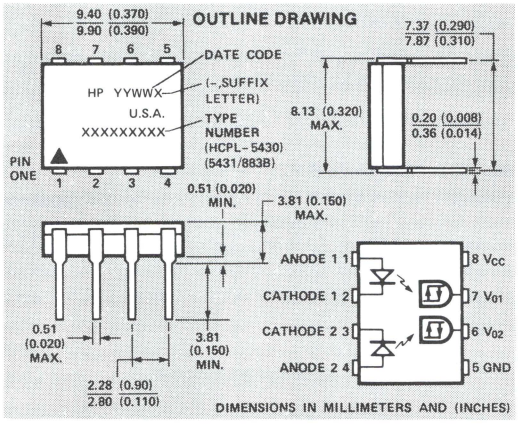
*Limits and conditions per Electrical Characteristics.

HEWLETT PACKARD

DUAL CHANNEL, HIGH SPEED, HERMETICALLY SEALED OPTOCOUPLER

HCPL-5430
HCPL-5431
(883B)





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- HERMETICALLY SEALED 8 PIN DUAL IN-LINE PACKAGE
- PERFORMANCE GUARANTEED OVER -55°C TO +125°C AMBIENT TEMPERATURE RANGE
- MIL-STD-883 CLASS B TESTING
- HIGH SPEED GUARANTEED OVER TEMPERATURE
- 75 ns MAXIMUM PROPAGATION DELAY
- 35 ns MAXIMUM PULSE WIDTH DISTORTION
- HIGH COMMON MODE REJECTION — 500 V/μs GUARANTEED
- COMPATIBLE WITH TTL, STTL, LSTTL, AND HCMOS LOGIC FAMILIES
- HIGH POWER SUPPLY NOISE IMMUNITY
- 500 Vdc WITHSTAND TEST VOLTAGE

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- ISOLATION OF HIGH SPEED LOGIC SYSTEMS
- COMPUTER-PERIPHERAL INTERFACES
- ISOLATED BUS DRIVER (NETWORKING APPLICATIONS)
- SWITCHING POWER SUPPLIES
- GROUND LOOP ELIMINATION
- HIGH SPEED DISK DRIVE I/O
- DIGITAL ISOLATION FOR A/D, D/A CONVERSION
- PULSE TRANSFORMER REPLACEMENT

Description

The HCPL-5430 and HCPL-5431 units are dual channel hermetically sealed, high speed optocouplers. The products are capable of operation and storage over the full military temperature range and can be purchased as either a standard product (HCPL-5430) or with full MIL-STD-883 Class Level B testing (HCPL-5431). Both products are in eight pin hermetic dual in-line packages.

Each unit contains two channels, consisting of an AlGaAs light emitting diode optically coupled to an integrated high speed photon detector. This combination results in very high data rate capability. The detector has a threshold with hysteresis. The hysteresis provides typically 0.25 mA of differential mode noise immunity and minimizes the potential for output signal chatter.

The HCPL-5430 and HCPL-5431 are compatible with TTL, STTL, LSTTL, and HCMOS logic families. The 35 ns pulse width distortion specification guarantees a 10 mBaud signaling rate at 125°C with 35% pulse width distortion. Figure 9 shows a recommended circuit for reducing pulse width distortion and improving the signaling rate of the product.

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	4.75	5.25	Volts
Input Current (High)	$I_{F\ (ON)}$	8	10	mA
Input Voltage (Low)	$V_{F\ (OFF)}$	—	0.7	Volts
Fan Out (each channel)	N		5	TTL Loads

Absolute Maximum Ratings

Storage Temperature ..... -65°C to +150°C
Operating Temperature ..... -55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 s
(1.6 mm below seating plane)
Average Forward Current — $I_{F\ AVG}$ ..... 10 mA
Peak Input Current — $I_{F\ PK}$ ..... 20 mA[1]
Reverse Input Voltage — V_R ..... 5 V
Supply Voltage — V_{CC} ..... 0 V min., 7.0 V max.
Average Output Current — I_O .... -25 mA min., 25 mA max.
Output Voltage — V_O ..... -0.5 V min., 10 V max.
Output Power Dissipation — P_O (per channel) ..... 130 mW
Total Package Power Dissipation P_d ..... 400 mW

Electrical Characteristics

T_A = -55°C to 125°C, 4.75 V ≤ V_{CC} ≤ 5.25 V, 8 mA ≤ $I_{F\ (ON)}$ ≤ 10 mA, 0 V ≤ $V_{F\ (OFF)}$ ≤ 0.7 V, unless otherwise specified.

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions	Figure	Note
Logic Low Output Voltage	V_{OL}			0.5	Volts	I_{OL} = 8.0 mA (5 TTL Loads)	1	9
Logic High Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -4.0 mA	2	9
Output Leakage Current	I_{OHH}			100	μA	V_O = 5.25 V, V_F = 0.7 V		9
Logic Low Supply Current	I_{CCL}		38	52	mA	V_{CC} = 5.25 V		
Logic High Supply Current	I_{CCH}		34	52	mA	V_E = 0 V		
Input Forward Voltage	V_F	1.0	1.4	1.85	Volts	I_F = 10 mA	4	9
Input Reverse Breakdown Voltage	V_R	5.0	7.0		Volts	I_R = 10 μA		9
Input-Output Insulation Leakage Current	I_{I-O}			1	μA	45% RH, t = 5 s, V_{I-O} = 500 Vdc, T_A = 25°C		2, 3
Propagation Delay Time to Logic Low Output Level	t_{PHL}		33	75	ns	$I_{F\ (ON)}$ = 9 mA	5, 6, 7	4, 9
Propagation Delay Time to Logic High Output Level	t_{PLH}		30	65	ns	$I_{F\ (ON)}$ = 9 mA	5, 6, 7	4, 9
Pulse Width Distortion	$\|t_{PHL}-t_{PLH}\|$		3	35	ns	$I_{F\ (ON)}$ = 9 mA	5, 6	9
Logic High Common Mode Transient Immunity	$\|CM_H\|$	500	3000		V/μs	T_A = 25°C, I_F = 0	8	5, 9
Logic Low Common Mode Transient Immunity	$\|CM_L\|$	500	3000		V/μs	T_A = 25°C, I_F = 8 mA	8	5, 9

*All typical values are at V_{CC} = 5 V, T_A = 25°C, I_F = 9 mA except where noted.

Typical Characteristics All typicals V_{CC} = 5 V, T_A = 25°C, I_F = 9 mA except where noted.

Parameter	Symbol	Typ.	Units	Test Conditions	Figure	Note
Input Current Hysteresis	I_{HYS}	0.25	mA	V_{CC} = 5 V	3	
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$	-1.11	mV/°C	I_F = 10 mA	4	
Input-Output Resistance	R_{I-O}	10^{12}	ohms	V_{I-O} = 500 VDC		2
Input-Output Capacitance	C_{I-O}	0.6	pF	f = 1 MHz, V_{I-O} = 0 Vdc		2
Input Capacitance	C_{IN}	15	pF	f = 1 MHz, V_O = 0 V, Pins 1 and 2, Pins 3 and 4		
Input-Input Capacitance	C_{I-I}	1.3	pF	f = 1 MHz, V_F = 0 V		8
Input-Input Leakage Current	I_{I-I}	0.5	nA	V_{I-I} = 500 VDC, 45% RH		8
Input-Input Resistance	R_{I-I}	10^{12}	ohms	V_{I-I} = 500 VDC		8
Logic Low Short Circuit Output Current	I_{OSL}	65	mA	V_O = V_{CC} = 5.25 V, I_F = 10 mA		6, 9
Logic High Short Circuit Output Current	I_{OSH}	-50	mA	V_{CC} = 5.25 V, I_F = 0 mA, V_O = GND		6, 9
Output Rise Time (10-90%)	t_r	15	ns		5	
Output Fall Time (90-10%)	t_f	10	ns		5	
Power Supply Noise Immunity	PSNI	0.5	V_{p-p}	48 Hz ≤ f_{AC} ≤ 50 MHz		7

Notes:

1. Not to exceed 5% duty factor, not to exceed 50μsec pulse width.
2. Device considered a two terminal device: pins 1-4 shorted together, and pins 5-8 shorted together.
3. This is momentary withstand test, not an operating condition.
4. t_{PHL} propagation delay is measured from the 50% level on the rising edge of the input current pulse to the 1.5 V level on the falling edge of the output pulse. The t_{PLH} propagation delay is measured from the 50% level on the falling edge of the input current pulse to the 1.5 V level on the rising edge of the output pulse.
5. CM_H is the maximum slew rate of common mode voltage that can be sustained with the output voltage in the logic high state ($V_{O\,(MIN)}$ > 2.0 V). CM_L is the maximum slew rate of common mode voltage that can be sustained with the output voltage in the logic low state ($V_{O\,(MAX)}$ < 0.8 V).
6. Duration of output short circuit time not to exceed 10 ms.
7. Power Supply Noise Immunity is the peak to peak amplitude of the ac ripple voltage on the V_{CC} line that the device will withstand and still remain in the desired logic state. For desired logic high state, $V_{OH(MIN)}$ > 2.0 V, and for desired logic low state, $V_{OL(MAX)}$ < 0.8 volts.
8. Measured between pins 1, 2 shorted together and pins 3, 4 shorted together.
9. Each channel.

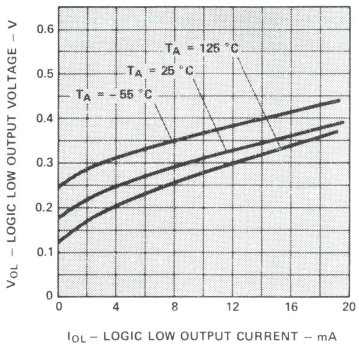


Figure 1. Typical Logic Low Output Voltage vs. Logic Low Output Current

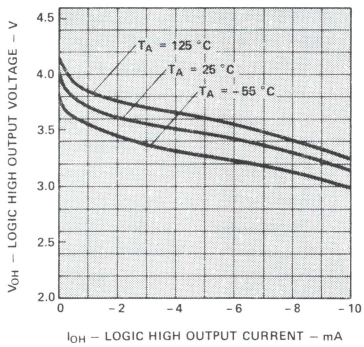


Figure 2. Typical Logic High Output Voltage vs. Logic High Output Current

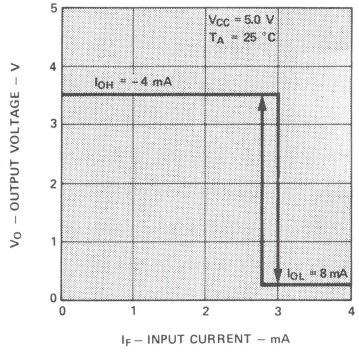


Figure 3. Typical Output Voltage vs. Input Forward Current

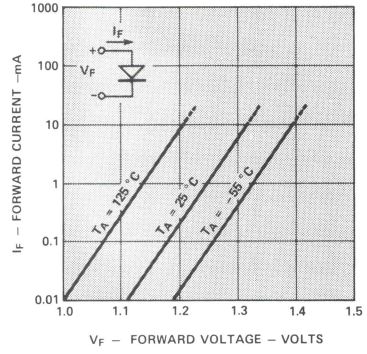


Figure 4. Typical Diode Input Forward Current Characteristic

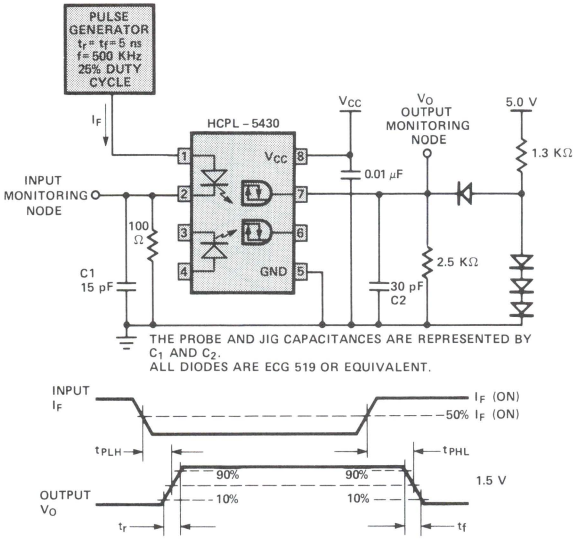


Figure 5. Test Circuit for t_{PLH}, t_{PHL}, t_r, and t_f

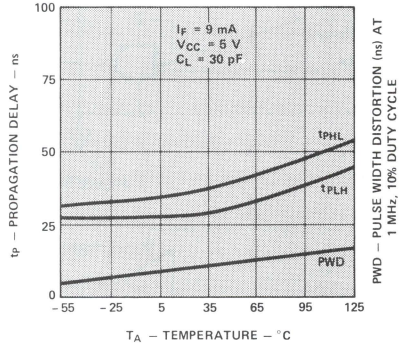


Figure 6. Typical Propagation Delay vs. Ambient Temperature

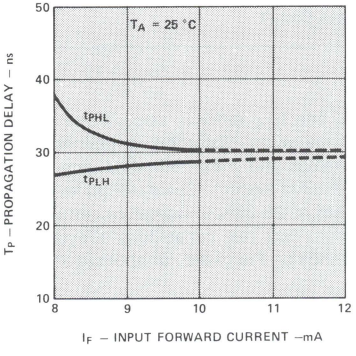
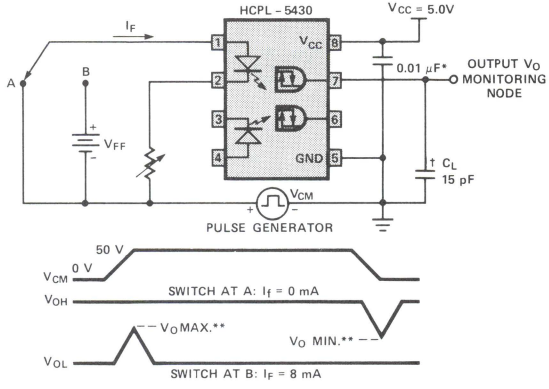


Figure 7. Typical Propagation Delay vs. Input Forward Current



*TOTAL LEAD LENGTH < 10 mm FROM DEVICE UNDER TEST.
**SEE NOTE 5.
†C_L IS APPROXIMATELY 15 pF, WHICH INCLUDES PROBE AND STRAY WIRING CAPACITANCE.

Figure 8. Test Diagram for Common Mode Transient Immunity and Typical Waveforms

Applications

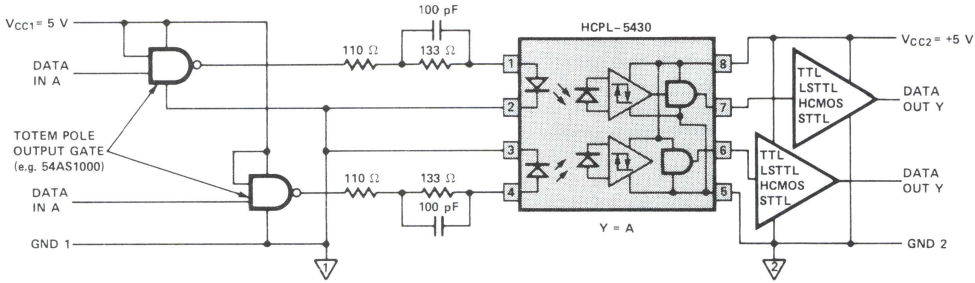


Figure 9. Recommended HCPL-5430 Interface Circuit

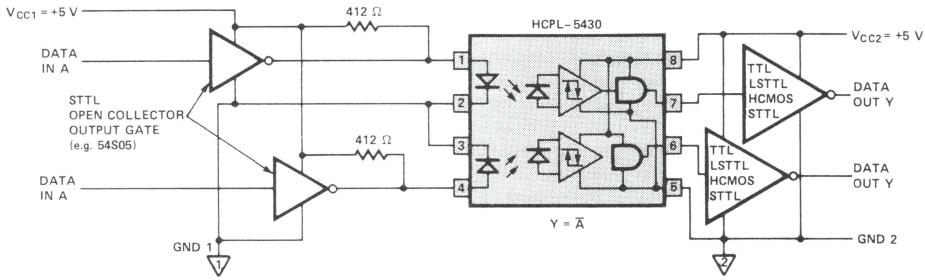


Figure 10. Alternative HCPL-5430 Interface Circuit

Data Rate and Pulse-Width Distortion Definitions

Propagation delay is a figure of merit which describes the finite amount of time required for a system to translate information from input to output when shifting logic levels. Propagation delay from low to high (t_{PLH}) specifies the amount of time required for a system's output to change from a Logic 0 to a Logic 1, when given a stimulus at the input. Propagation delay from high to low (t_{PHL}) specifies the amount of time required for a system's output to change from a Logic 1 to a Logic 0, when given a stimulus at the input (see Figure 5).

When t_{PLH} and t_{PHL} differ in value, pulse width distortion results. Pulse width distortion is defined as $|t_{PHL}-t_{PLH}|$ and determines the maximum data rate capability of a distortion-limited system. Maximum pulse width distortion on the order of 25–35% is typically used when specifying the maximum data rate capabilities of systems. The exact figure depends on the particular application (RS-232, PCM, T-1, etc.).

The HCPL-5430 optocoupler offers the advantages of specified propagation delay (t_{PLH}, t_{PHL}), and pulse-width distortion ($|t_{PLH}-t_{PHL}|$) over temperature and power supply voltage ranges.

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's HCPL-5431 optocoupler is in compliance with MIL-STD-883, Revision C. Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

See table below for specific electrical tests.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
HCPL-5430	HCPL-5431

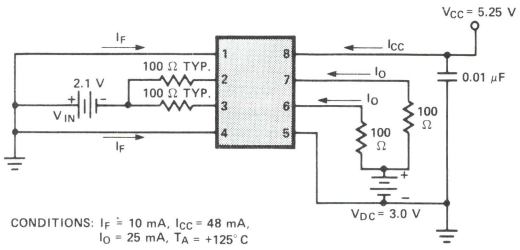


Figure 11. Operating Circuit for Burn-In and Steady State Life Tests

GROUP A — ELECTRICAL TESTS

QUANTITY/ACCEPT NO. = 116/0

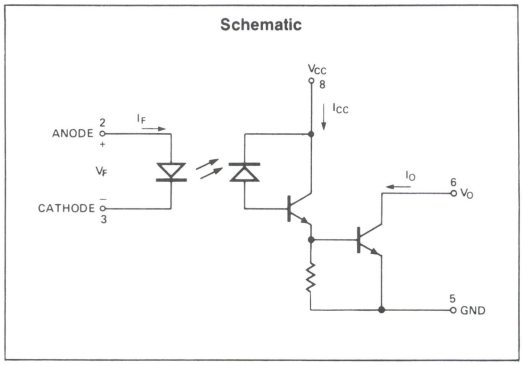
Subgroup 1 *Static tests at T_A = 25°C — V_{OL}, V_{OH}, I_{OHH}, I_{CCL}, I_{CCH}, V_F, V_R, I_{I-O}
Subgroup 2 *Static tests at T_A = +125°C — V_{OL}, V_{OH}, I_{OHH}, I_{CCL}, I_{CCH}, V_F, V_R
Subgroup 3 *Static tests at T_A = -55°C — V_{OL}, V_{OH}, I_{OHH}, I_{CCL}, I_{CCH}, V_F, V_R
Subgroup 4, 5, 6, 7, 8A and 8B These subgroups are not applicable to this device type.
Subgroup 9 *Switching tests at T_A = 25°C — t_{PHL}, t_{PLH}, $\|t_{PHL}-t_{PLH}\|$, $\|CM_H\|$, $\|CM_L\|$
Subgroup 10 *Switching tests at T_A = +125°C — t_{PHL}, t_{PLH}, $\|t_{PHL}-t_{PLH}\|$
Subgroup 11 *Switching tests at T_A = -55°C — t_{PHL}, t_{PLH}, $\|t_{PHL}-t_{PLH}\|$

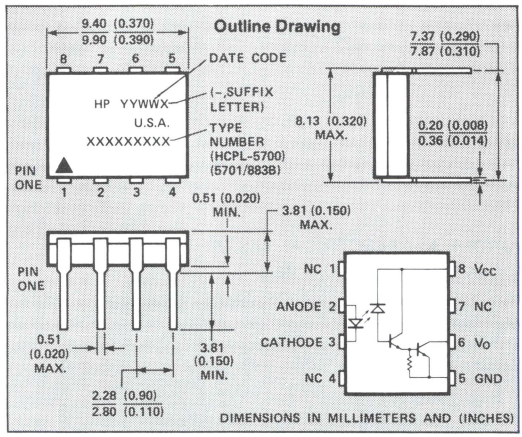
*Limits and conditions per Electrical Characteristics.

HEWLETT PACKARD

LOW INPUT CURRENT, HIGH GAIN, HERMETICALLY SEALED OPTOCOUPLER

HCPL-5700
HCPL-5701
(883B)





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- HERMETICALLY SEALED 8 PIN DUAL IN-LINE PACKAGE
- PERFORMANCE GUARANTEED OVER –55° C TO +125° C AMBIENT TEMPERATURE RANGE
- MIL-STD-883 CLASS B TESTING
- 6N138, 6N139 AND 6N140A OPERATING COMPATIBILITY
- LOW INPUT CURRENT REQUIREMENT — 0.5 mA
- HIGH CURRENT TRANSFER RATIO — 1500% TYPICAL
- LOW OUTPUT SATURATION VOLTAGE — 0.11 V TYPICAL
- 500 Vdc WITHSTAND TEST VOLTAGE
- HIGH COMMON MODE REJECTION
- LOW POWER CONSUMPTION
- HIGH RADIATION IMMUNITY

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- TELEPHONE RING DETECTION
- MICROPROCESSOR SYSTEM INTERFACE
- EIA RS-232-C LINE RECEIVER
- LEVEL SHIFTING
- DIGITAL LOGIC GROUND ISOLATION
- CURRENT LOOP RECEIVER
- ISOLATED INPUT LINE RECEIVER
- SYSTEM TEST EQUIPMENT ISOLATION
- PROCESS CONTROL INPUT/OUTPUT ISOLATION

Description

The HCPL-5700 and 5701 units are hermetically sealed, low input current, high gain optocouplers. The products are capable of operation and storage over the full military temperature range and can be purchased as either a standard product (HCPL-5700) or with full MIL-STD-883 Class Level B testing (HCPL-5701). Both products are in eight pin hermetic dual in-line packages.

Each unit contains an AlGaAs light emitting diode which is optically coupled to an integrated high gain photon detector. The high gain output stage features an open collector output providing both lower output saturation voltage and higher signaling speed than possible with conventional photo-darlington optocouplers.

The supply voltage can be operated as low as 2.0 V without adversely affecting the parametric performance.

The HCPL-5700 and HCPL-5701 have a 200% minimum CTR at an input current of only 0.5 mA making them ideal for use in low input current applications such as MOS, CMOS, low power logic interfaces or line receivers. Compatibility with high voltage CMOS logic systems is assured by the 18 V V_{CC}, V_{OH} current and the guaranteed maximum output leakage current at 18 V. The shallow depth and small junctions offered by the IC process provides better radiation immunity than conventional phototransistor optocouplers.

Upon special request, the following device selections can be made: CTR minimum of 300% to 600% at 0.5 mA, lower drive currents to 0.1 mA, and lower output leakage current levels to 100 μA.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Input Voltage, Low Level	V_{FL}		0.7	V
Average Input Current High Level	I_{FH}	0.5	5	mA
Supply Voltage	V_{CC}	2.0	18	V

Absolute Maximum Ratings

Storage Temperature ..... –65°C to +150°C
Operating Temperature ..... –55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 sec.
(1.6 mm below the seating plane)
Output Current I_O ..... 40 mA
Output Voltage V_O ..... –0.5 V to 20 V[1]
Supply Voltage V_{CC} ..... –0.5 to 20 V[1]
Output Power Dissipation ..... 50 mW[2]
Peak Input Current ..... 8 mA
Reverse Input Voltage, V_R ..... 5 V

Electrical Characteristics $T_A = -55°C$ to 125°C, unless otherwise specified

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR	200 200 200	1500 1000 500		% % %	I_F = 0.5 mA, V_O = 0.4 V, V_{CC} = 4.5 V I_F = 1.6 mA, V_O = 0.4 V, V_{CC} = 4.5 V I_F = 5 mA, V_O = 0.4 V, V_{CC} = 4.5 V	3	3
Logic Low Output Voltage	V_{OL}		0.11 0.13 0.16	0.4 0.4 0.4	V V V	I_F = 0.5 mA, I_O = 1.0 mA, V_{CC} = 4.5 V I_F = 1.6 mA, I_O = 3.2 mA, V_{CC} = 4.5 V I_F = 5.0 mA, I_O = 10 mA, V_{CC} = 4.5 V	2	
Logic High Output Current	I_{OH}		0.001	250	μA	V_F = 0.7 V, V_O = V_{CC} = 18 V		
Logic Low Supply Current	I_{CCL}		1.0	2.0	mA	I_F = 1.6 mA, V_{CC} = 18 V	4	
Logic High Supply Current	I_{CCH}		0.001	7.5	μA	I_{F1} = 0, V_{CC} = 18 V		
Input Forward Voltage	V_F	1.0	1.3	1.6	V	I_F = 1.6 mA, T_A = 25°C	1	
Input Reverse Breakdown Voltage	BV_R	5			V	I_R = 10 μA		
Input-Output Insulation Leakage Current	I_{I-O}			1.0	μA	45% Relative Humidity, T_A = 25°C t = 5 sec, V_{I-O} = 500 Vdc		4, 5
Propagation Delay Time to Logic High At Output	t_{PLH}		17	185	μs	I_F = 0.5 mA, R_L = 4.7 kΩ, V_{CC} = 5 V	7,8	
			14	115	μs	I_F = 1.6 mA, R_L = 2.2 kΩ, V_{CC} = 5 V	7,8	
			8	60	μs	I_F = 5.0 mA, R_L = 680 Ω, V_{CC} = 5 V	7,8	
Propagation Delay Time to Logic Low At Output	t_{PHL}		10	185	μs	I_F = 0.5 mA, R_L = 4.7 kΩ, V_{CC} = 5 V	7,8	
			5	30	μs	I_F = 1.6 mA, R_L = 2.2 kΩ, V_{CC} = 5 V	7,8	
			2	12	μs	I_F = 5.0 mA, R_L = 680 Ω, V_{CC} = 5 V	7,8	
Common Mode Transient Immunity At Logic High Level Output	$\|CM_H\|$	500	≥2000		V/μs	I_F = 0, R_L = 2.2 kΩ $\|V_{CM}\|$ = 50 V_{p-p}, V_{CC} = 5.0 V, T_A = 25°C	9,10	6, 8
Common Mode Transient Immunity At Logic Low Level Output	$\|CM_L\|$	500	≥1000		V/μs	I_F = 1.6 mA, R_L = 2.2 kΩ $\|V_{CM}\|$ = 50 V_{p-p}, V_{CC} = 5.0 V, T_A = 25°C	9,10	7, 8

*All typical values are at V_{CC} = 5 V, T_A = 25°C.

Typical Characteristics $T_A = 25°C$, V_{CC} = 5 V

Parameter	Symbol	Typ.	Units	Test Conditions	Fig.	Note
Resistance (Input-Output)	R_{I-O}	10^{12}	Ω	V_{I-O} = 500 Vdc		9
Capacitance (Input-Output)	C_{I-O}	2.0	pF	f = 1 MHz		9
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$	–1.5	mV/°C	I_F = 1.6 mA		
Input Capacitance	C_{IN}	15	pF	f = 1 MHz, V_F = 0		

NOTES:
1. GND Pin should be the most negative voltage at the detector side. Keeping V_{CC} as low as possible, but greater than 2.0 V, will provide lowest total I_{OH} over temperature.
2. Output power is collector output power plus one half of total supply power.
3. CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
4. Device considered a two-terminal device. Pins 1 through 4 are shorted together and pins 5 through 8 are shorted together.
5. This is a momentary withstand test, not an operating condition.
6. CM_H is the maximum tolerable common mode transient such that the output will remain in a high logic state (i.e. V_O > 2.0 V).
7. CM_L is the maximum tolerable common mode transient such that the output will remain in a low logic state (i.e. V_O < 0.8 V).
8. In applications where dV/dt may exceed 50,000 V/μs (such as a static discharge) a series resistor, R_{CC}, is recommended to protect the detector IC from destructively high surge currents. The recommended maximum value is

$$R_{CC} \approx \frac{1V}{0.15\ I_F\ (mA)}\ k\Omega.$$

9. Measured between the LED anode and cathode shorted together and pins 5 through 8 shorted together.

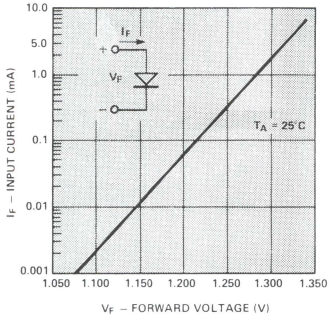


Figure 1. Input Current vs. Forward Voltage.

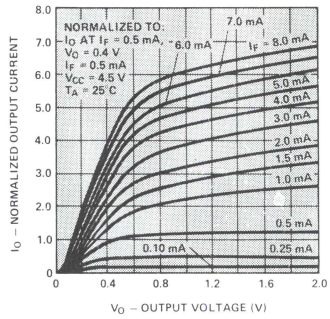


Figure 2. Normalized DC Transfer Characteristics.

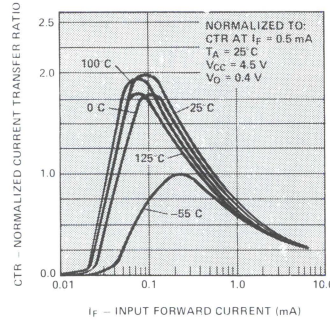


Figure 3. Normalized Current Transfer Ratio vs. Input Forward Current.

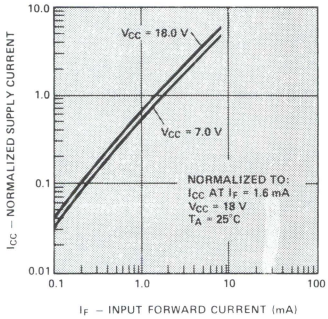


Figure 4. Normalized Supply Current vs. Input Forward Current.

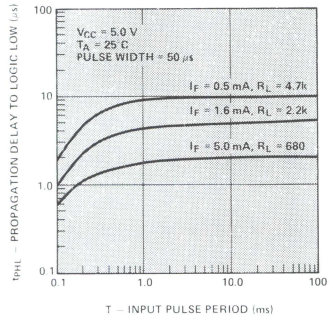


Figure 5. Propagation Delay to Logic Low vs. Input Pulse Period.

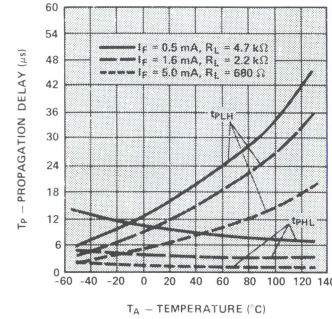


Figure 6. Propagation Delay vs. Temperature.

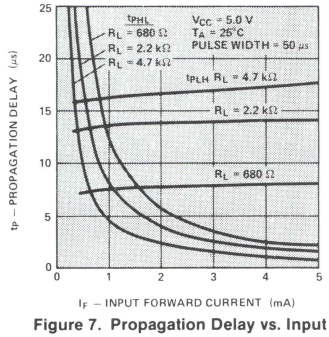


Figure 7. Propagation Delay vs. Input Forward Current.

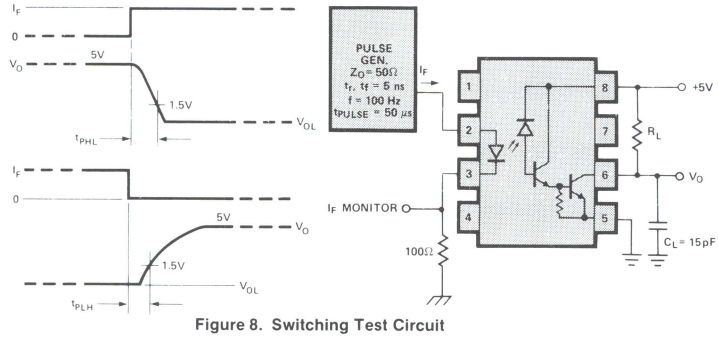
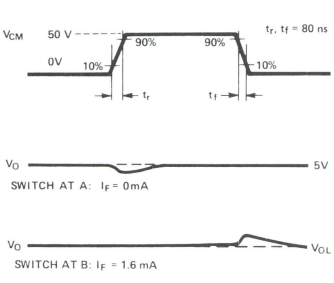


Figure 8. Switching Test Circuit



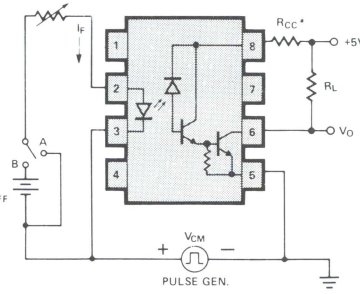


Figure 9. Test Circuit for Transient Immunity and Typical Waveforms

*See Note 8

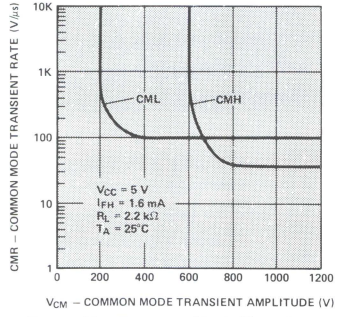


Figure 10. Common Mode Transient Immunity vs. Common Mode Transient Amplitude

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's HCPL-5701 optocoupler is in compliance with MIL-STD-883, Revision C. Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

See table below for specific electrical tests.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
HCPL-5700	HCPL-5701

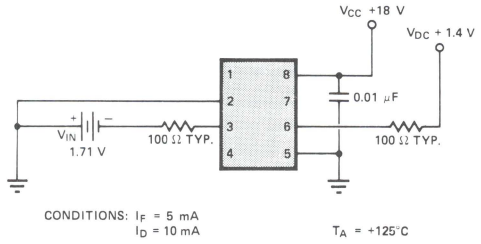


Figure 11. Operating Circuit for Burn-In and Steady State Life Tests

GROUP A — ELECTRICAL TESTS

QUANTITY/ACCEPT NO. = 116/0

Subgroup 1
*Static tests at $T_A = 25°C$ — I_{OH}, V_{OL}, I_{CCL}, I_{CCH}, CTR, V_F, BV_R and I_{I-O}

Subgroup 2
*Static tests at $T_A = +125°C$ — I_{OH}, V_{OL}, I_{CCL}, I_{CCH}, BV_R and CTR

Symbol	Min.	Max.	Units	Test Conditions
V_F		1.8	V	$I_F = 1.6$ mA

Subgroup 3
*Static tests at $T_A = -55°C$ — I_{OH}, V_{OL}, I_{CCL}, I_{CCH}, BV_R and CTR

Symbol	Min.	Max.	Units	Test Conditions
V_F		1.8	V	$I_F = 1.6$ mA

Subgroup 4, 5, 6, 7, 8A and 8B
These subgroups are not applicable to this device type.

Subgroup 9
*Switching tests at $T_A = 25°C$ – t_{PLH1}, t_{PHL1}, t_{PLH2}, t_{PHL2}, t_{PLH3}, t_{PHL3}, CM_H and CM_L

Subgroup 10
*Switching tests at $T_A = +125°C$ – t_{PLH1}, t_{PHL1}, t_{PLH2}, t_{PHL2}, t_{PLH3}, t_{PHL3}

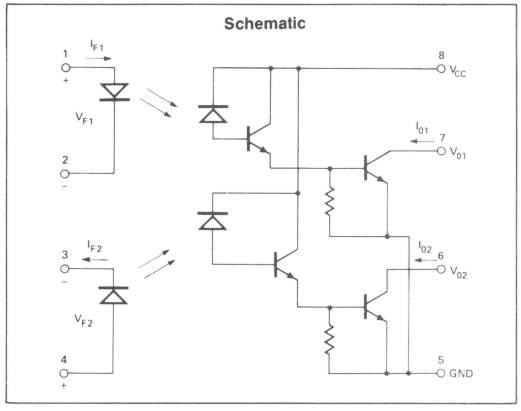
Subgroup 11
*Switching tests at $T_A = -55°C$ – t_{PLH1}, t_{PHL1}, t_{PLH2}, t_{PHL2}, t_{PLH3}, t_{PHL3}

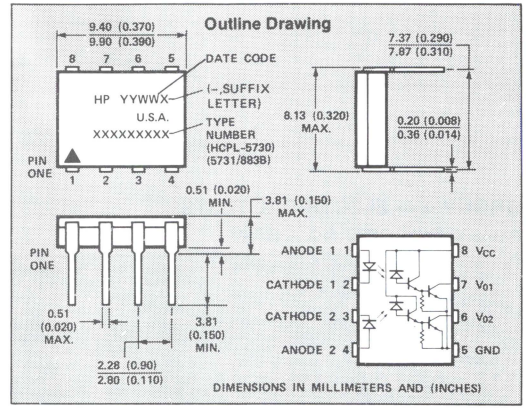
*Limits and conditions per Table II.

HEWLETT PACKARD

DUAL CHANNEL LOW INPUT CURRENT, HIGH GAIN, HERMETICALLY SEALED OPTOCOUPLER

HCPL-5730
HCPL-5731
(883B)





Features

- NEW — MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- HERMETICALLY SEALED 8 PIN DUAL IN-LINE PACKAGE
- PERFORMANCE GUARANTEED OVER –55° C TO +125° C AMBIENT TEMPERATURE RANGE
- MIL-STD-883 CLASS B TESTING
- HCPL-2730/2731 AND 6N140A OPERATING COMPATIBILITY
- LOW INPUT CURRENT REQUIREMENT — 0.5 mA
- HIGH CURRENT TRANSFER RATIO — 1500% TYPICAL
- LOW OUTPUT SATURATION VOLTAGE — 0.11 V TYPICAL
- 500 Vdc WITHSTAND TEST VOLTAGE
- HIGH COMMON MODE REJECTION
- LOW POWER CONSUMPTION
- HIGH RADIATION IMMUNITY

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- TELEPHONE RING DETECTION
- MICROPROCESSOR SYSTEM INTERFACE
- EIA RS-232-C LINE RECEIVER
- LEVEL SHIFTING
- DIGITAL LOGIC GROUND ISOLATION
- CURRENT LOOP RECEIVER
- ISOLATED INPUT LINE RECEIVER
- SYSTEM TEST EQUIPMENT ISOLATION
- PROCESS CONTROL INPUT/OUTPUT ISOLATION

Description

The HCPL-5730 and HCPL-5731 units are dual channel, hermetically sealed, low input current, high gain optocouplers. The products are capable of operation and storage over the full military temperature range and can be purchased as either a standard product (HCPL-5730) or with full MIL-STD-883 Class Level B testing (HCPL-5731). Both products are in eight pin hermetic dual in-line packages.

Each unit contains two independent channels, consisting of an AlGaAs light emitting diode optically coupled to an integrated high gain photon detector. The high gain output stage features an open collector output providing both lower output saturation voltage and higher signaling speed than possible with conventional photo-darlington optocouplers.

The supply voltage can be operated as low as 2.0 V without adversely affecting the parametric performance.

The HCPL-5730 and HCPL-5731 have a 200% minimum CTR at an input current of only 0.5 mA making them ideal for use in low input current applications such as MOS, CMOS, low power logic interfaces or line receivers. Compatibility with high voltage CMOS logic systems is assured by the 18 V V_{CC}, V_{OH} current and the guaranteed maximum output leakage current at 18 V. The shallow depth and small junctions offered by the IC process provides better radiation immunity than conventional phototransistor optocouplers.

Upon special request, the following device selections can be made: CTR minimum of 300% to 600% at 0.5 mA, lower drive currents to 0.1 mA, and lower output leakage current levels to 100 μA.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Input Voltage, Low Level (Each Channel)	V_{FL}		0.7	V
Average Input Current High Level (Each Channel)	I_{FH}	0.5	5	mA
Supply Voltage	V_{CC}	2.0	18	V

Absolute Maximum Ratings

Storage Temperature ..... −65°C to +150°C
Operating Temperature ..... −55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 sec. (1.6 mm below the seating plane)
Output Current I_O (Each Channel) ..... 40 mA
Output Voltage V_O (Each Channel) ..... −0.5 V to 20 V[1]
Supply Voltage V_{CC} ..... −0.5 to 20 V[1]
Output Power Dissipation (Each Channel) .... 50 mW[2]
Peak Input Current (Each Channel) ..... 8 mA
Reverse Input Voltage, V_R (Each Channel) ..... 5 V

Electrical Characteristics $T_A = -55°C$ to 125°C, unless otherwise specified

Parameter	Symbol	Min.	Typ.*	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR	200 200 200	1500 1000 500		% % %	$I_F = 0.5$ mA, $V_O = 0.4$ V, $V_{CC} = 4.5$ V $I_F = 1.6$ mA, $V_O = 0.4$ V, $V_{CC} = 4.5$ V $I_F = 5$ mA, $V_O = 0.4$ V, $V_{CC} = 4.5$ V	3	3, 4
Logic Low Output Voltage	V_{OL}		0.11 0.13 0.16	0.4 0.4 0.4	V V V	$I_F = 0.5$ mA, $I_O = 1.0$ mA, $V_{CC} = 4.5$ V $I_F = 1.6$ mA, $I_O = 3.2$ mA, $V_{CC} = 4.5$ V $I_F = 5.0$ mA, $I_O = 10$ mA, $V_{CC} = 4.5$ V	2	3
Logic High Output Current	I_{OHX} I_{OH}		0.001	250	μA	$V_F = 0.7$ V (Channel Under Test) $I_F = 8$ mA (Other Channel) $V_O = V_{CC} = 18$ V		3, 5
Logic Low Supply Current	I_{CCL}		1.0	4	mA	$I_{F1} = I_{F2} = 1.6$ mA $V_{CC} = 18$ V	4	
Logic High Supply Current	I_{CCH}		0.001	15	μA	$I_{F1} = I_{F2} = 0$ $V_{CC} = 18$ V		
Input Forward Voltage	V_F	1.0	1.3	1.6	V	$I_F = 1.6$ mA, $T_A = 25°C$	1	3
Input Reverse Breakdown Voltage	BV_R	5			V	$I_R = 10$ μA		3
Input-Output Insulation Leakage Current	I_{I-O}			1.0	μA	45% Relative Humidity, $T_A = 25°C$ $t = 5$ sec, $V_{I-O} = 500$ Vdc		6, 12
Propagation Delay Time to Logic High At Output	t_{PLH}		17	185	μs	$I_F = 0.5$ mA, $R_L = 4.7$ kΩ, $V_{CC} = 5$ V	7,8	3
			14	115	μs	$I_F = 1.6$ mA, $R_L = 2.2$ kΩ, $V_{CC} = 5$ V	7,8	3
			8	60	μs	$I_F = 5.0$ mA, $R_L = 680$ Ω, $V_{CC} = 5$ V	7,8	3
Propagation Delay Time to Logic Low At Output	t_{PHL}		10	185	μs	$I_F = 0.5$ mA, $R_L = 4.7$ kΩ, $V_{CC} = 5$ V	7,8	3
			5	30	μs	$I_F = 1.6$ mA, $R_L = 2.2$ kΩ, $V_{CC} = 5$ V	7,8	3
			2	12	μs	$I_F = 5.0$ mA, $R_L = 680$ Ω, $V_{CC} = 5$ V	7,8	3
Common Mode Transient Immunity At Logic High Level Output	$\|CM_H\|$	500	≥2000		V/μs	$I_F = 0$, $R_L = 2.2$ kΩ $\|V_{CM}\| = 50\ V_{p-p}$, $V_{CC} = 5.0$ V, $T_A = 25°C$	9,10	3 9, 11
Common Mode Transient Immunity At Logic Low Level Output	$\|CM_L\|$	500	≥1000		V/μs	$I_F = 1.6$ mA, $R_L = 2.2$ kΩ $\|V_{CM}\| = 50\ V_{p-p}$, $V_{CC} = 5.0$ V, $T_A = 25°C$	9,10	3 10, 11

*All typical values are at $V_{CC} = 5$ V, $T_A = 25°C$.

Typical Characteristics $T_A = 25°C$, $V_{CC} = 5$ V

Parameter	Symbol	Typ.	Units	Test Conditions	Fig.	Note
Resistance (Input-Output)	R_{I-O}	10^{12}	Ω	$V_{I-O} = 500$ Vdc		3, 7
Capacitance (Input-Output)	C_{I-O}	2.0	pF	$f = 1$ MHz		3,7
Input-Input Insulation Leakage Current	I_{I-I}	0.5	nA	45% Relative Humidity, $V_{I-I} = 500$ Vdc $T_A = 25°C$, $t = 5$s.		8
Resistance (Input-Input)	R_{I-I}	10^{12}	Ω	$V_{I-I} = 500$ Vdc		8
Capacitance (Input-Input)	C_{I-I}	1.3	pF	$f = 1$ MHz		8
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$	−1.5	mV/°C	$I_F = 1.6$ mA		3
Input Capacitance	C_{IN}	15	pF	$f = 1$ MHz, $V_F = 0$		3

NOTES:

1. GND Pin should be the most negative voltage at the detector side. Keeping V_{CC} as low as possible, but greater than 2.0 V, will provide lowest total I_{OH} over temperature.
2. Output power is collector output power plus one half of total supply power.
3. Each channel.
4. CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
5. I_{OHX} is the leakage current resulting from channel to channel optical crosstalk. $V_F = 0.7$ V for channel under test.
6. Device considered a two-terminal device: Pins 1 through 4 are shorted together and pins 5 through 8 are shorted together.
7. Measured between the LED anode and cathode shorted together and pins 5 through 8 shorted together.
8. Measured between adjacent input pairs shorted together, i.e. between pins 1 and 2 shorted together and pins 3 and 4 shorted together.
9. CM_H is the maximum tolerable common mode transient such that the output will remain in a high logic state (i.e. $V_O > 2.0$ V).
10. CM_L is the maximum tolerable common mode transient such that the output will remain in a low logic state (i.e. $V_O < 0.8$ V).
11. In applications where dV/dt may exceed 50,000 V/μs (such as a static discharge) a series resistor, R_{CC}, is recommended to protect the detector IC's from destructively high surge currents. The recommended maximum value is

$$R_{CC} = \frac{1\text{V}}{0.3\ I_F\ (\text{mA})}\ \text{k}\Omega.$$

12. This is a momentary withstand test, not an operating condition.

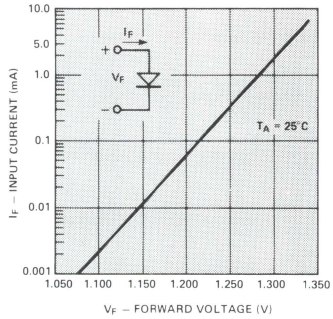


Figure 1. Input Current vs. Forward Voltage.

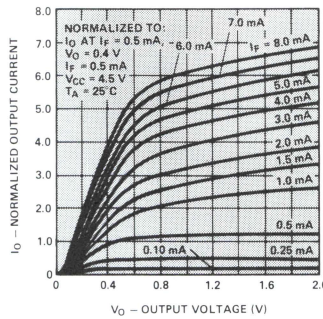


Figure 2. Normalized DC Transfer Characteristics.

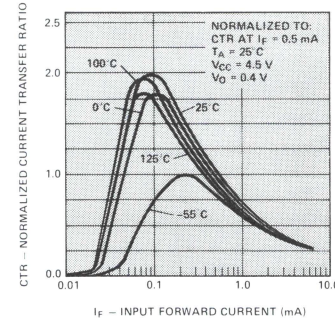


Figure 3. Normalized Current Transfer Ratio vs. Input Forward Current.

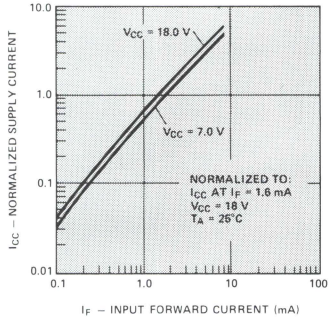


Figure 4. Normalized Supply Current vs. Input Forward Current.

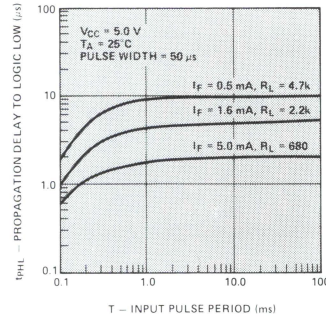


Figure 5. Propagation Delay to Logic Low vs. Input Pulse Period.

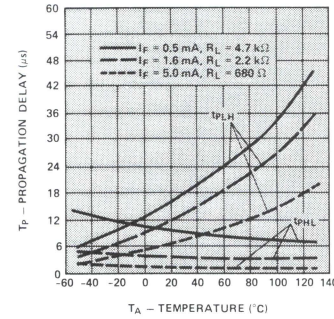


Figure 6. Propagation Delay vs. Temperature.

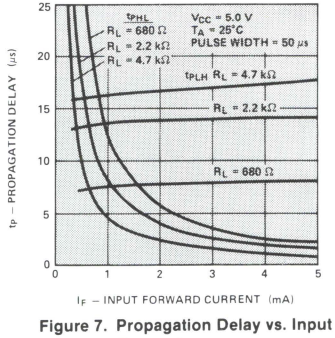


Figure 7. Propagation Delay vs. Input Forward Current.

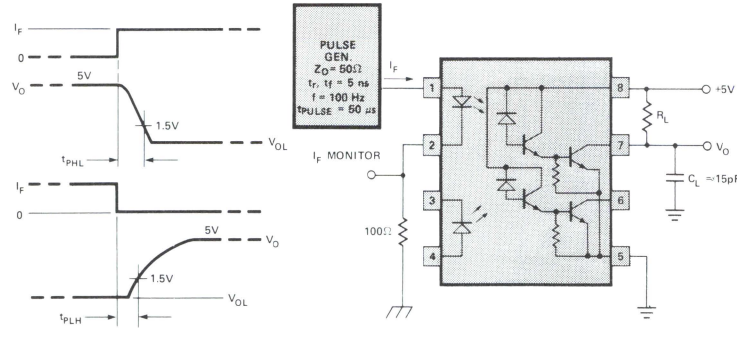


Figure 8. Switching Test Circuit.

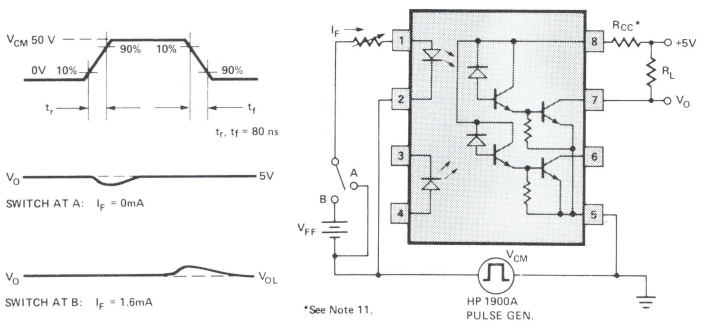


Figure 9. Test Circuit for Transient Immunity and Typical Waveforms.

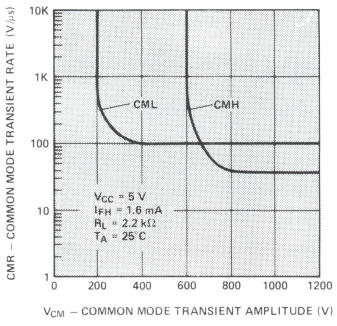


Figure 10. Common Mode Transient Immunity vs. Common Mode Transient Amplitude.

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's HCPL-5731 optocoupler is in compliance with MIL-STD-883, Revision C. Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

See table below for specific electrical tests.

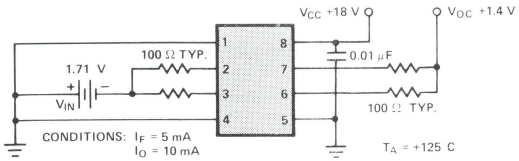


Figure 11. Operating Circuit for Burn-In and Steady State Life Tests.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
HCPL-5730	HCPL-5731

GROUP A — ELECTRICAL TESTS

QUANTITY/ACCEPT NO. = 116/0

Subgroup 1
*Static tests at T_A = 25°C – I_{OH}, I_{OHX}, V_{OL}, I_{CCL}, I_{CCH}, CTR, V_F, BV_R and I_{I-O}

Subgroup 2
*Static tests at T_A = +125°C — I_{OH}, I_{OHX}, V_{OL}, I_{CCL}, I_{CCH}, BV_R and CTR

Symbol	Min.	Max.	Units	Test Conditions
V_F		1.8	V	I_F = 1.6 mA

Subgroup 3
*Static tests at T_A = –55°C — I_{OH}, I_{OHX}, V_{OL}, I_{CCL}, I_{CCH}, BV_R and CTR

Symbol	Min.	Max.	Units	Test Conditions
V_F		1.8	V	I_F = 1.6 mA

Subgroup 4, 5, 6, 7, 8A and 8B
These subgroups are not applicable to this device type.

Subgroup 9
*Switching tests at T_A = 25°C – t_{PLH1}, t_{PHL1}, t_{PLH2}, t_{PHL2}, t_{PLH3}, t_{PHL3}, CM_H and CM_L

Subgroup 10
*Switching tests at T_A = +125°C – t_{PLH1}, t_{PHL1}, t_{PLH2}, t_{PHL2}, t_{PLH3}, t_{PHL3}

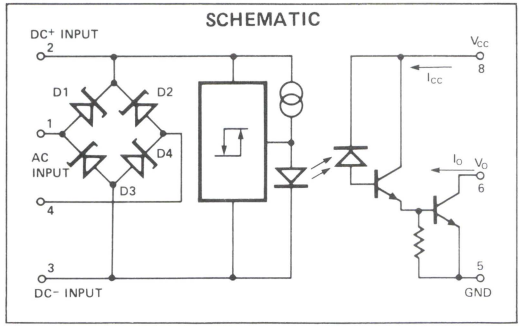
Subgroup 11
*Switching tests at T_A = –55°C – t_{PLH1}, t_{PHL1}, t_{PLH2}, t_{PHL2}, t_{PLH3}, t_{PHL3}

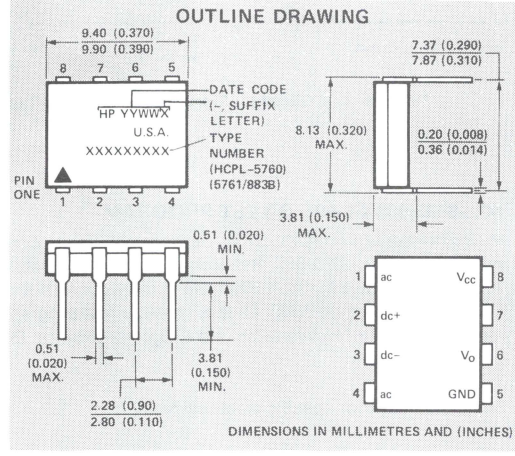
*Limits and conditions per Table II.

HEWLETT PACKARD

AC/DC TO LOGIC INTERFACE HERMETICALLY SEALED OPTOCOUPLER

HCPL-5760
HCPL-5761
(883B)



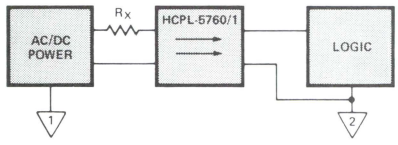


Features

- MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- HERMETICALLY SEALED 8 PIN DUAL IN-LINE PACKAGE
- PERFORMANCE GUARANTEED OVER -55°C TO +125°C AMBIENT TEMPERATURE RANGE
- MIL-STD-883 CLASS B TESTING
- AC OR DC INPUT
- PROGRAMMABLE SENSE VOLTAGE
- HYSTERESIS
- LOGIC COMPATIBLE OUTPUT
- HCPL-3700 OPERATING COMPATIBILITY
- 500 Vdc WITHSTAND TEST VOLTAGE
- THRESHOLDS GUARANTEED OVER TEMPERATURE
- THRESHOLDS INDEPENDENT OF LED CHARACTERISTICS

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- LIMIT SWITCH SENSING
- LOW VOLTAGE DETECTOR
- AC/DC VOLTAGE SENSING
- RELAY CONTACT MONITOR
- RELAY COIL VOLTAGE MONITOR
- CURRENT SENSING
- MICROPROCESSOR INTERFACING
- TELEPHONE RING DETECTION



Description

The HCPL-5760 and HCPL-5761 units are hermetically sealed, voltage/current threshold detection optocouplers. The products are capable of operation and storage over the full military temperature range and can be purchased as either a standard product (HCPL-5760) or with full MIL-STD-883 Class Level B testing (HCPL-5761). Both products are in eight pin hermetic dual in-line packages.

Each unit contains an AlGaAs light emitting diode (LED), a threshold sensing input buffer IC, and a high gain photon detector to provide an optocoupler which permits adjustable external threshold levels. The input buffer circuit has a nominal turn on threshold of 2.5 mA (I_{TH+}) and 3.6 volts (V_{TH+}). The addition of one or more external attenuation resistors permits the use of this device over a wide range of input voltages and currents. Threshold sensing prior to the LED and detector elements minimizes effects of different optical gain and LED variations over operating life (CTR degradation). Hysteresis is also provided in the buffer for extra noise immunity and switching stability.

The buffer circuit is designed with internal clamping diodes to protect the circuitry and LED from a wide range of over-voltage and over-current transients while the diode bridge enables easy use with ac voltage input.

The HCPL-5760/1, by combining several unique functions in a single package, provides the user with an ideal component for computer input boards and other applications where a predetermined input threshold optocoupler level is desirable.

The high gain output stage features an open collector output providing both TTL compatible saturation voltages and CMOS compatible breakdown voltages.

Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Power Supply Voltage	V_{CC}	3.0	18	Volts
Operating Frequency[1]	f	0	10	KHz

Absolute Maximum Ratings

Storage Temperature ..... -65°C to +150°C
Operating Temperature ..... -55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 s[2]
Average Input Current — I_{IN} ..... 15 mA[3]
Surge Input Current — $I_{IN,SG}$ ..... 140 mA[3,4]
Peak Transient Input Current — $I_{IN,PK}$ ..... 500 mA[3,4]
Input Power Dissipation — P_{IN} ..... 195 mW[5]
Total Package Power Dissipation — P_d ..... 225 mW
Output Power Dissipation — P_O ..... 50 mW
Average Output Current — I_O ..... 40 mA
Supply Voltage — V_{CC} (Pins 8-5) .... -0.5 V min., 20 V max.
Output Voltage — V_O (Pins 6-5) ..... -0.5 V min., 20 V max.

Electrical Characteristics T_A = -55°C to 125°C, unless otherwise specified.

Parameter		Symbol	Min.	Typ.*	Max.	Units	Conditions	Fig.	Note
Input Threshold Current		I_{TH+}	1.75	2.5	3.20	mA	$V_{IN} = V_{TH+}$; V_{CC} = 4.5 V; V_O = 0.4 V; $I_O \geq$ 2.6 mA	1, 2	7
		I_{TH-}	0.93	1.3	1.62	mA	$V_{IN} = V_{TH-}$; V_{CC} = 4.5 V; V_O = 2.4 V; $I_{OH} \leq 250\ \mu A$		
Input Threshold Voltage	dc (Pins 2, 3)	V_{TH+}	3.18	3.6	4.10	V	$V_{IN} = V_2 - V_3$; Pins 1 & 4 Open V_{CC} = 4.5 V; V_O = 0.4 V; $I_O \geq$ 2.6 mA		
		V_{TH-}	1.90	2.5	3.00	V	$V_{IN} = V_2 - V_3$; Pins 1 & 4 Open V_{CC} = 4.5 V; V_O = 2.4 V; $I_O \leq 250\ \mu A$		
	ac (Pins 1, 4)	V_{TH+}	3.79	5.0	5.62	V	$V_{IN} = \lvert V_1 - V_4 \rvert$; Pins 2 & 3 Open V_{CC} = 4.5 V; V_O = 0.4 V; $I_O \geq$ 2.6 mA		7, 8
		V_{TH-}	2.57	3.7	4.52	V	$V_{IN} = \lvert V_1 - V_4 \rvert$; Pins 2 & 3 Open V_{CC} = 4.5 V; V_O = 2.4 V; $I_O \leq 250\ \mu A$		
Input Clamp Voltage		V_{IHC1}	5.3	5.9	6.7	V	$V_{IHC1} = V_2 - V_3$; V_3 = GND I_{IN} = 10 mA; Pin 1 & 4 Connected to Pin 3	3	
		V_{IHC2}	6.0	6.6	7.4	V	$V_{IHC2} = \lvert V_1 - V_4 \rvert$; $\lvert I_{IN} \rvert$ = 10 mA; Pins 2 & 3 Open		
		V_{IHC3}		12.0	13.0	V	$V_{IHC3} = V_2 - V_3$; V_3 = GND, I_{IN} = 15 mA, Pins 1 & 4 Open		
Input Current		I_{IN}	3.0	3.9	4.5	mA	$V_{IN} = V_2 - V_3$ = 5.0 V; Pins 1 & 4 Open	4	
Logic Low Output Voltage		V_{OL}		0.1	0.4	V	V_{CC} = 4.5 V; I_{OL} = 2.6 mA	4	7
Logic High Output Current		I_{OH}			250	μA	$V_{OH} = V_{CC}$ = 18 V		
Logic Low Supply Current		I_{CCL}		0.05	2.0	mA	$V_2 - V_3$ = 5.0 V; V_O = Open V_{CC} = 18 V		
Logic High Supply Current		I_{CCH}		0.001	7.5	μA	V_{CC} = 18 V; V_O = Open	5	
Input-Output Insulation		I_{I-O}			1	μA	45% RH, t = 5 s, V_{I-O} = 500 Vdc, T_A = 25°C		9, 10
Propagation Delay Time to Logic Low Output Level		t_{PHL}		7	20	μs	R_L = 1.8 kΩ, C_L = 15 pF	6, 7	6, 11
Propagation Delay Time to Logic High Output Level		t_{PLH}		4	25	μs	R_L = 1.8 kΩ, C_L = 15 pF		6, 12
Logic High Common Mode Transient Immunity		$\lvert CM_H \rvert$	1000	≥10,000		V/μs	V_{CM} = 50 V	T_A = 25°C I_{IN} = 0 mA	8	13, 14
				≥10,000			V_{CM} = 450 V		
Logic Low Common Mode Transient Immunity		$\lvert CM_L \rvert$	1000	≥5,000		V/μs	V_{CM} = 50 V	T_A = 25°C I_{IN} = 4 mA	
				≥5,000			V_{CM} = 250 V		

* All typical values are at T_A = 25°C, V_{CC} = 5 V, unless otherwise specified.

Typical Characteristics

All typical values are at V_{CC} = 5 V, T_A = 25°C unless otherwise specified.

Parameter	Symbol	Typ.	Units	Conditions	Fig.	Note
Hysteresis	I_{HYS}	1.2	mA	$I_{HYS} = I_{TH+} - I_{TH-}$	1	
	V_{HYS}	1.1	V	$V_{HYS} = V_{TH+} - V_{TH-}$		
Input Clamp Voltage	V_{ILC}	-0.76	V	$V_{ILC} = V_2 - V_3$; V_3 = GND; I_{IN} = -10 mA		
Bridge Diode Forward Voltage	$V_{D1,2}$	0.62		I_{IN} = 3 mA (see schematic)		
	$V_{D3,4}$	0.73				
Input-Output Resistance	R_{I-O}	10^{12}	Ω	V_{I-O} = 500 Vdc		9
Input-Output Capacitance	C_{I-O}	2.0	pF	f = 1 MHz, V_{I-O} = 0 Vdc		9
Input Capacitance	C_{IN}	50	pF	f = 1 MHz; V_{IN} = 0 V, Pins 2 & 3, Pins 1 & 4 Open		
Output Rise Time (10-90%)	t_r	10	μs		7	
Output Fall Time (90-10%)	t_f	0.5	μs		7	

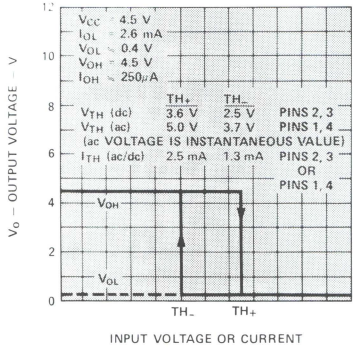


Figure 1. Typical Transfer Characteristics (ac voltage is instantaneous value.)

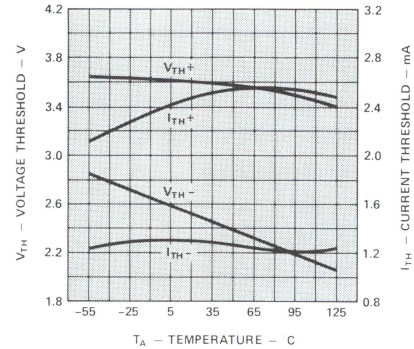


Figure 2. Typical dc Threshold Levels vs. Temperature.

Notes:

1. Maximum operating frequency is defined when output waveform (Pin 6) attains only 90% of V_{CC} with R_L = 1.8 kΩ, C_L = 15 pF using a 5 V square wave input signal.
2. Measured at a point 1.6 mm below seating plane.
3. Current into/out of any single lead.
4. Surge input current duration is 3 ms at 120 Hz pulse repetition rate. Transient input current duration is 10 μs at 120 Hz pulse repetition rate. Note that maximum input power, P_{IN}, must be observed.
5. Derate linearly above 100°C free-air temperature at a rate of 4.26 mW/°C. Maximum input power dissipation of 195 mW allows an input IC junction temperature of 150°C at an ambient temperature of T_A = 125°C with a typical thermal resistance from junction to ambient of θ_{JA_i} = 235°C/W. The typical thermal resistance from junction to case is equal to 170°C/W. Excessive P_{IN} and T_J may result in device degradation.
6. The 1.8 kΩ load represents 1 TTL unit load of 1.6 mA and the 4.7 kΩ pull-up resistor.
7. Logic low output level at Pin 6 occurs under the conditions of $V_{IN} \geq V_{TH+}$ as well as the range of $V_{IN} > V_{TH-}$ once V_{IN} has exceeded V_{TH+}. Logic high output level at Pin 6 occurs under the conditions of $V_{IN} \leq V_{TH-}$ as well as the range of $V_{IN} < V_{TH+}$ once V_{IN} has decreased below V_{TH-}.
8. The ac voltage is instantaneous voltage.
9. Device considered a two terminal device: pins 1, 2, 3, 4 connected together, and Pins 5, 6, 7, 8 connected together.
10. This is a momentary withstand test, not an operating condition.
11. The t_{PHL} propagation delay is measured from the 2.5 V level of the leading edge of a 5.0 V input pulse (1 μs rise time) to the 1.5 V level on the leading edge of the output pulse (see Figure 7).
12. The t_{PLH} propagation delay is measured from the 2.5 V level of the trailing edge of a 5.0 V input pulse (1 μs fall time) to the 1.5 V level on the trailing edge of the output pulse (see Figure 7).
13. Common mode transient immunity in Logic High level is the maximum tolerable dV_{CM}/dt of the common mode voltage, V_{CM}, to ensure that the output will remain in a Logic High state (i.e., $V_O > 2.0$ V). Common mode transient immunity in Logic Low level is the maximum tolerable dV_{CM}/dt of the common mode voltage, V_{CM}, to ensure that the output will remain in a Logic Low state (i.e., $V_O < 0.8$ V). See Figure 8.
14. In applications where dV_{CM}/dt may exceed 50,000 V/μs (such as static discharge), a series resistor, R_{CC}, should be included to protect the detector IC from destructively high surge currents. The recommended value for R_{CC} is 240Ω per volt of allowable drop in V_{CC} (between Pin 8 and V_{CC}) with a minimum value of 240Ω.

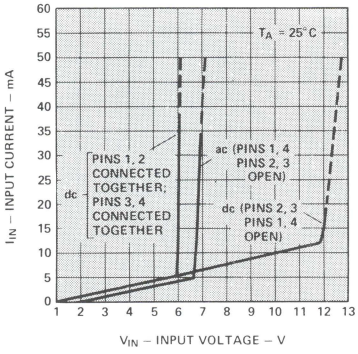


Figure 3. Typical Input Characteristics, I_{IN} vs. V_{IN}. (ac voltage is instantaneous value.)

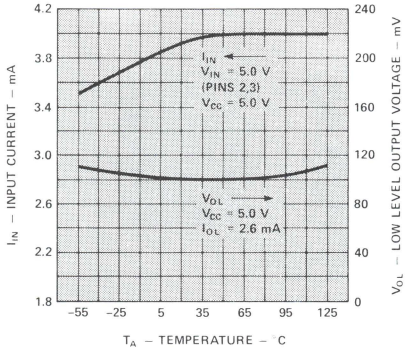


Figure 4. Typical Input Current, I_{IN}, and Low level Output Voltage, V_{OL}, vs. Temperature.

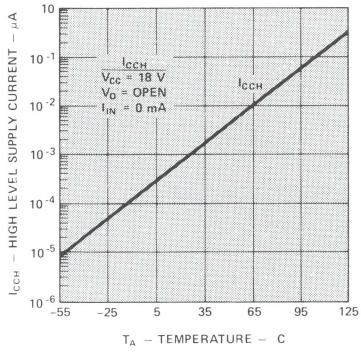


Figure 5. Typical High Level Supply Current, I_{CCH} vs. Temperature.

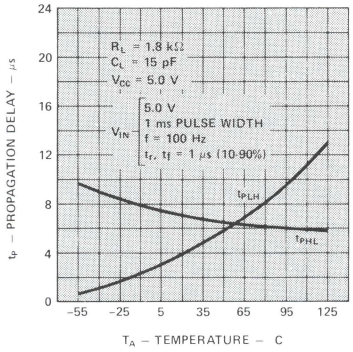
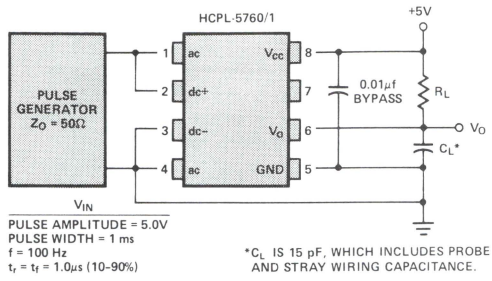


Figure 6. Typical Propagation Delay vs. Temperature.



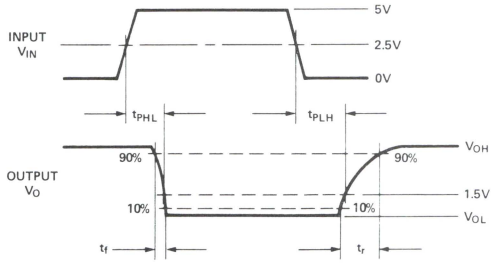
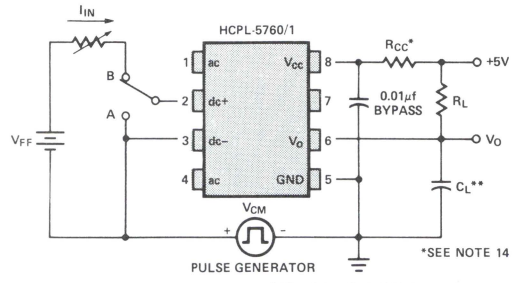


Figure 7. Switching Test Circuit.



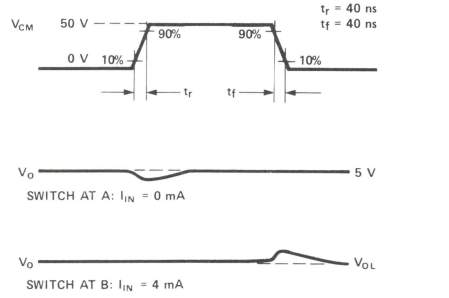


Figure 8. Test Circuit for Common Mode Transient Immunity and Typical Waveforms.

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's HCPL-5761 optocoupler is in compliance with MIL-STD-883, Revision C. Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

See table below for specific electrical tests.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
HCPL-5760	HCPL-5761

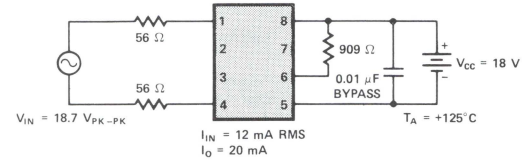


Figure 9. Operating Circuit for Burn-in and Steady State Life Tests

GROUP A — ELECTRICAL TESTS

QUANTITY/ACCEPT NO. = 116/0

Subgroup 1 *Static tests at T_A = 25°C — I_{TH+}, I_{TH-}, $V_{TH+(dc)}$, $V_{TH-(dc)}$, $V_{TH+(ac)}$, $V_{TH-(ac)}$, V_{IHC1}, V_{IHC2}, V_{IHC3}, I_{OH}, I_{CCL}, I_{CCH}
Subgroup 2 *Static tests at T_A = +125°C — I_{TH+}, I_{TH-}, $V_{TH+(dc)}$, $V_{TH-(dc)}$, $V_{TH+(ac)}$, $V_{TH-(ac)}$, V_{IHC1}, V_{IHC2}, V_{IHC3}, I_{OH}, I_{CCL}, I_{CCH}
Subgroup 3 *Static tests at T_A = -55°C — I_{TH+}, I_{TH-}, $V_{TH+(dc)}$, $V_{TH-(dc)}$, $V_{TH+(ac)}$, $V_{TH-(ac)}$, V_{IHC1}, V_{IHC2}, V_{IHC3}, I_{OH}, I_{CCL}, I_{CCH}
Subgroup 4, 5, 6, 7, 8A and 8B These subgroups are not applicable to this device type.
Subgroup 9 *Switching tests at T_A = 25°C — t_{PHL}, t_{PLH}, $\|CM_H\|$, $\|CM_L\|$
Subgroup 10 *Switching tests at T_A = +125°C — t_{PHL}, t_{PLH}
Subgroup 11 *Switching tests at T_A = -55°C — t_{PHL}, t_{PLH}

*Limits and conditions per Electrical Characteristics.

Electrical Considerations

The HCPL-5760/1 optocoupler has internal temperature compensated, predictable voltage and current threshold points which allow selection of an external resistor, R_X, to determine larger external threshold voltage levels. For a desired external threshold voltage, $V_{\pm}$, a corresponding typical value of R_X can be obtained from Figure 10. Specific calculation of R_X can be obtained from Equation (1) of Figure 11. Specification of both V_- and V_+ voltage threshold levels simultaneously can be obtained by the use of R_X and R_P as shown in Figure 11 and determined by Equations (2) and (3).

R_X can provide over-current transient protection by limiting input current during a transient condition. For monitoring contacts of a relay or switch, the HCPL-5760/1 in combination with R_X and R_P can be used to allow a specific current to be conducted through the contacts for cleaning purposes (wetting current).

The choice of which input voltage clamp level to choose depends upon the application of this device (see Figure 3). It is recommended that the low-clamp condition be used when possible to lower the input power dissipation as well as the LED current, which minimizes LED degradation over time.

In applications where $dV_{CM/dt}$ may be extremely large (such as static discharge), a series resistor, R_{CC}, should be connected in series with V_{CC} and Pin 8 to protect the detector IC from destructively high surge currents. See note 14 for determination of R_{CC}. In addition, it is recommended that a ceramic disc bypass capacitor of 0.01 μf to 0.1 μf be placed between Pins 8 and 5 to reduce the effect of power supply noise.

For interfacing ac signals to TTL systems, output low pass filtering can be performed with a pullup resistor of 1.5 Ω and 20 μf capacitor. This application requires a Schmitt trigger gate to avoid slow rise time chatter problems. For ac input applications, a filter capacitor can be placed across the dc input terminals for either signal or transient filtering.

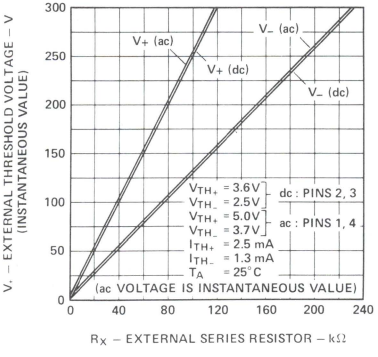


Figure 10. Typical External Threshold Characteristics, $V_{\pm}$ vs. R_X.

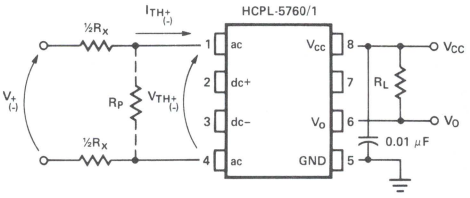


Figure 11. External Threshold Voltage Level Selection.

Either ac (Pins 1, 4) or dc (Pins 2, 3) input can be used to determine external threshold levels.

For one specifically selected external threshold voltage level V_+ or V_-, R_X can be determined without use of R_P via

$$R_X = \frac{V_+ - V_{TH+}}{I_{TH+}} \quad (1)$$

For two specifically selected external threshold voltage levels, V_+ and V_-, the use of R_X and R_P will permit this selection via equations (2), (3) provided the following conditions are met:

$$\frac{V_+}{V_-} \geq \frac{V_{TH+}}{V_{TH-}} \text{ and } \frac{V_+ - V_{TH+}}{V_- - V_{TH-}} < \frac{I_{TH+}}{I_{TH-}}$$

$$R_X = \frac{V_{TH-}(V_+) - V_{TH+}(V_-)}{I_{TH+}(V_{TH-}) - I_{TH-}(V_{TH+})} \quad (2)$$

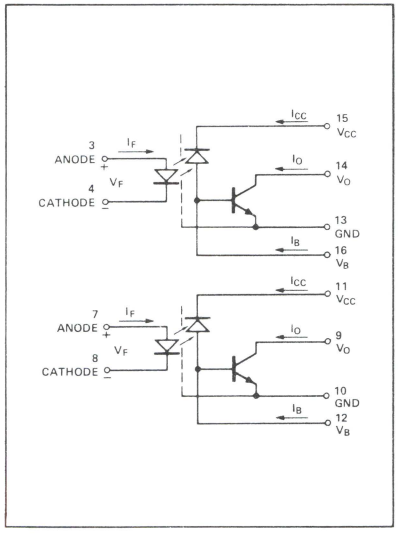
$$R_P = \frac{V_{TH-}(V_+) - V_{TH+}(V_-)}{I_{TH+}(V_- - V_{TH-}) + I_{TH-}(V_{TH+} - V_+)} \quad (3)$$

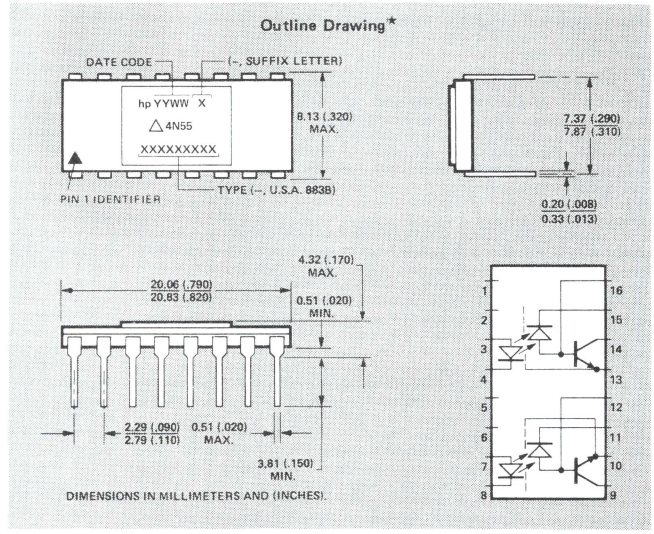
See Application Note 1004 for more information.

HEWLETT PACKARD

DUAL CHANNEL HERMETICALLY SEALED OPTOCOUPLER

4N55
4N55/883B





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- PERFORMANCE GUARANTEED OVER -55°C TO +125°C AMBIENT TEMPERATURE RANGE
- MIL-STD-883 CLASS B TESTING
- HERMETICALLY SEALED
- HIGH SPEED: TYPICALLY 400k BIT/S
- 2 MHz BANDWIDTH
- OPEN COLLECTOR OUTPUTS
- 18 VOLT V_{CC}
- DUAL-IN-LINE PACKAGE
- 1500 Vdc WITHSTAND TEST VOLTAGE
- HIGH RADIATION IMMUNITY
- HCPL-2530/2531 FUNCTION COMPATIBILITY

Applications

- HIGH RELIABILITY SYSTEMS
- LINE RECEIVERS
- DIGITAL LOGIC GROUND ISOLATION
- ANALOG SIGNAL GROUND ISOLATION
- SWITCHING POWER SUPPLY FEEDBACK ELEMENT
- VEHICLE COMMAND/CONTROL
- SYSTEM TEST EQUIPMENT
- LEVEL SHIFTING

Description

The 4N55 consists of two completely independent optocouplers in a hermetically sealed ceramic package. Each channel has a light emitting diode and an integrated photon detector. Separate connections for the photodiodes and output transistor collectors improve the speed up to a hundred times that of a conventional phototransistor optocoupler by reducing the base-collector capacitance.

The 4N55 is suitable for wide bandwidth analog applications, as well as for interfacing TTL to LSTTL or CMOS. Current Transfer Ratio (CTR) is 9% minimum at I_F = 16mA over the full military operating temperature range, -55°C to +125°C. The 18V V_{CC} capability will enable the designer to interface any TTL family to CMOS. The availability of the base lead allows optimized gain/bandwidth adjustment in analog applications. The shallow depth of the IC photodiode provides better radiation immunity than conventional phototransistor couplers.

Hewlett-Packard's new high reliability part type 4N55/883B meets Class B testing requirements for MIL-STD-883. This part is the recommended and preferred device from the 4N55 product family for use in high reliability applications.

See the selection guide at the front of this section for other devices in this family.

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

*JEDEC Registered Data

Absolute Maximum Ratings*

Storage Temperature ..... -65°C to +150°C
Operating Temperature ..... -55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 s (1.6mm below seating plane)
Average Input Current, I_F (each channel) 20mA
Peak Input Current, I_F (each channel, ≤ 1ms duration) 40mA
Reverse Input Voltage, V_R (each channel) 5V
Input Power Dissipation (each channel) 36mW
Average Output Current, I_O (each channel) 8mA
Peak Output Current, I_O (each channel) 16mA
Supply Voltage, V_{CC} (each channel) ..... -0.5V to 20V
Output Voltage, V_O (each channel) ..... -0.5V to 20V
Emitter Base Reverse Voltage, V_{EBO} 3.0V
Base Current, I_B (each channel) 5mA
Output Power Dissipation (each channel) 50mW
Derate linearly above 100°C free air temperature at a rate of 1.4mW/°C.

TABLE I.

Recommended Operating Conditions (EACH CHANNEL)

	Symbol	Min.	Max.	Units
Input Current, Low Level	I_{FL}		250	μA
Supply Voltage	V_{CC}	2	18	V

TABLE II.

Electrical Characteristics T_A = -55°C to +125°C, unless otherwise specified

Parameter	Symbol	Min.	Typ.**	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR*	9	20		%	I_F=16mA, V_O=0.4V, V_{CC}=4.5V	2,3	1,2
Logic High Output Current	I_{OH}		10	100	μA	I_F=0, I_F (other channel)=20mA V_O=V_{CC}=18V	4	1
Output Leakage Current	I_{OH1}*		30	250	μA	I_F=250μA, I_F (other channel)=20mA V_O=V_{CC}=18V	4	1
Logic Low Supply Current	I_{CCL}*		35	200	μA	I_{F1}=I_{F2}=20mA, V_{CC}=18V	5	1
Logic High Supply Current	I_{CCH}*		0.1	10	μA	I_F=0mA, I_F (other channel)=20mA V_{CC}=18V		1
Input Forward Voltage	V_F*		1.5	1.8	V	I_F=20mA	1	1
Input Reverse Breakdown Voltage	B_{VR}*	3			V	I_R=10μA		1
Input-Output Insulation Leakage Current	I_{I-O}*			1.0	μA	45% Relative Humidity, T_A=25°C, t=5s, V_{I-O}=1500Vdc		3,9
Propagation Delay Time to Logic High at Output	t_{PLH}*		1.0	6.0	μs	R_L=8.2KΩ, C_L=50pF I_F=16mA, V_{CC}=5V	6,9	1
Propagation Delay Time to Logic Low at Output	t_{PHL}*		0.4	2.0	μs	R_L=8.2KΩ, C_L=50pF I_F=16mA, V_{CC}=5V	6,9	1

*JEDEC Registered Data.
**All typical values are at V_{CC} = 5V, T_A = 25°C.

TABLE III.

Typical Characteristics at T_A=25°C

Parameter	Symbol	Typ.	Units	Test Conditions	Fig.	Note
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$	-1.5	mV/°C	I_F = 20 mA		1
Input Capacitance	C_{in}	120	pF	f=1 MHz, V_F=0		1
Resistance (Input-Output)	R_{I-O}	10^{12}	Ω	V_{I-O}=500 Vdc		1
Capacitance (Input-Output)	C_{I-O}	1.0	pF	f=1 MHz		1,4
Input-Input Insulation Leakage Current	I_{I-I}	1	pA	45% Relative Humidity, V_{I-I}=500Vdc, t=5s		5
Capacitance (Input-Input)	C_{I-I}	.55	pF	f=1 MHz		5
Transistor DC Current Gain	h_{FE}	150	—	V_O=5V, I_O=3mA		1
Small Signal Current Transfer Ratio	$\frac{\Delta I_O}{\Delta I_F}$	21	%	V_{CC}=5V, V_O=2V	7	1
Common Mode Transient Immunity at Logic High Level Output	$\lvert CM_H \rvert$	1000	V/μs	I_F=0, R_L=8.2kΩ V_{CM}=10V_{p-p} V_O (min.) = 2.0 V	10	1,6
Common Mode Transient Immunity at Logic Low Level Output	$\lvert CM_L \rvert$	1000	V/μs	I_F=16mA, R_L=8.2kΩ V_{CM}=10V_{p-p} V_O (max.) = 0.8 V	10	1,7
Bandwidth	BW	2	MHz	R_L=100Ω	8	8

Notes:
1. Each channel.
2. Current Transfer Ratio is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%. CTR is known to degrade slightly over the unit's lifetime as a function of input current, temperature, signal duty cycle and system on time. Refer to Application Note 1002 for more detail. In short it is recommended that designers allow at least 20-25% guardband for CTR degradation.
3. Measured between pins 1 through 8 shorted together and pins 9 through 16 shorted together.
4. Measured between each input pair shorted together and the output pins for that channel shorted together.
5. Measured between pins 3 and 4 shorted together and pins 7 and 8 shorted together.
6. CM_H is the steepest slope (dV/dt) on the leading edge of the common mode pulse, V_{CM}, for which the output will remain in the logic high state (i.e. $V_O > 2.0$ V).
7. CM_L is the steepest slope (dV/dt) on the trailing edge of the common mode pulse, V_{CM}, for which the output will remain in the logic low state (i.e. $V_O < 0.8$ V).
8. Bandwidth is the frequency at which the ac output voltage is 3dB below the low frequency asymptote.
9. This is a momentary withstand test, not an operating condition.

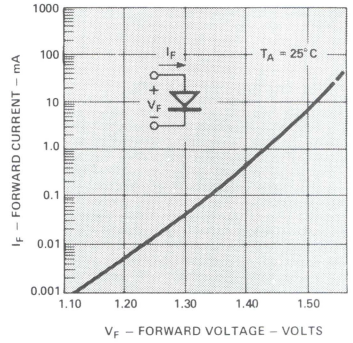


Figure 1. Input Diode Forward Characteristic.

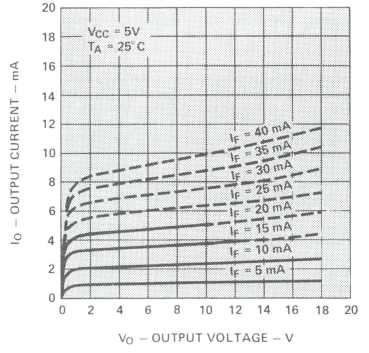


Figure 2. DC and Pulsed Transfer Characteristic

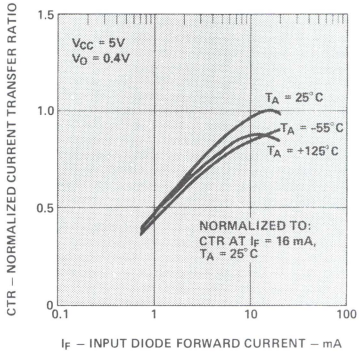


Figure 3. Normalized Current Transfer Ratio vs. Input Diode Forward Current.

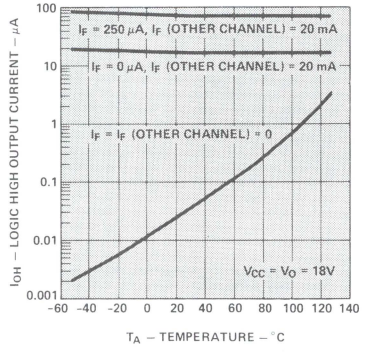


Figure 4. Logic High Output Current vs. Temperature.

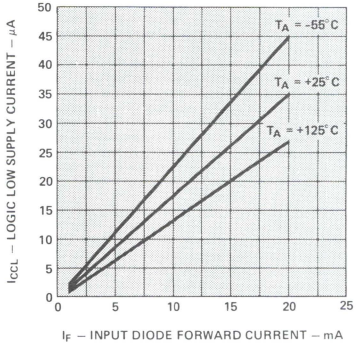


Figure 5. Logic Low Supply Current vs. Input Diode Forward Current.

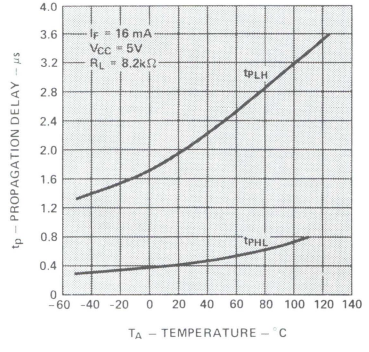


Figure 6. Propagation Delay vs. Temperature.

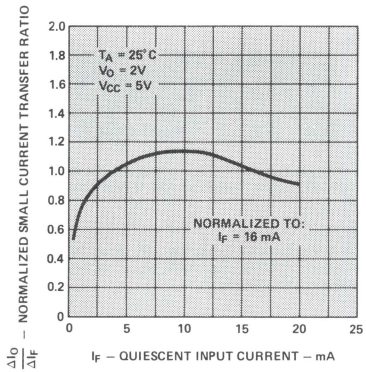


Figure 7. Normalized Small Signal Current Transfer Ratio vs. Quiescent Input Current.

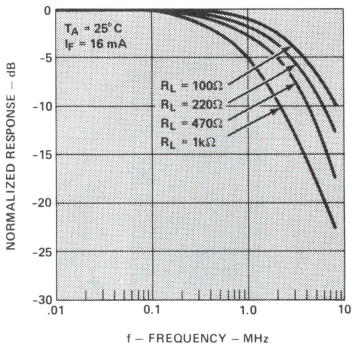


Figure 8a. Frequency Response

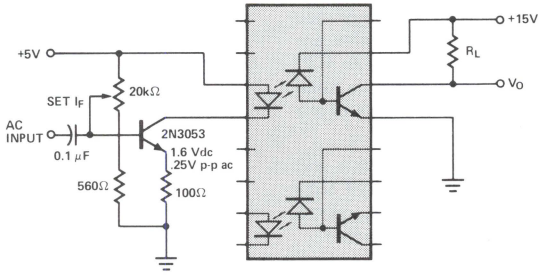
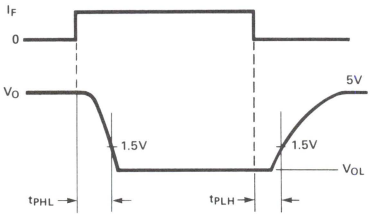


Figure 8b. Frequency Response



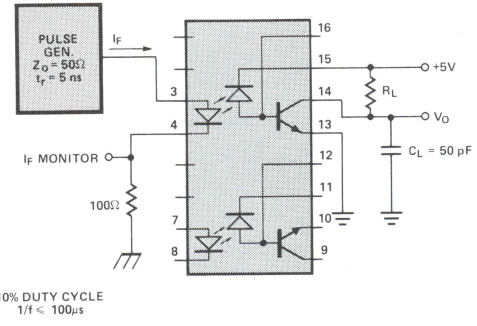
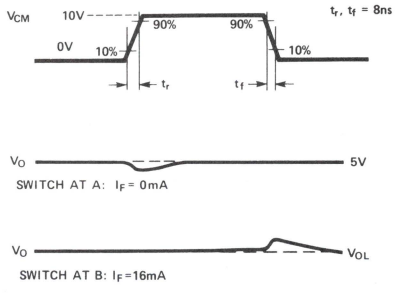


Figure 9. Switching Test Circuit*.



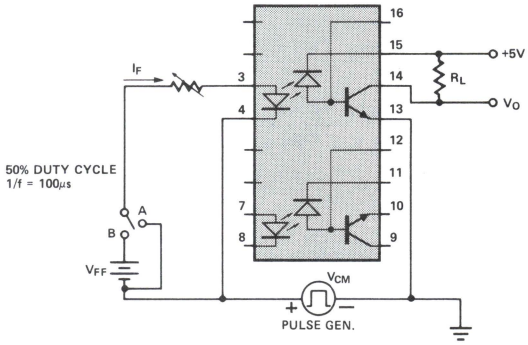
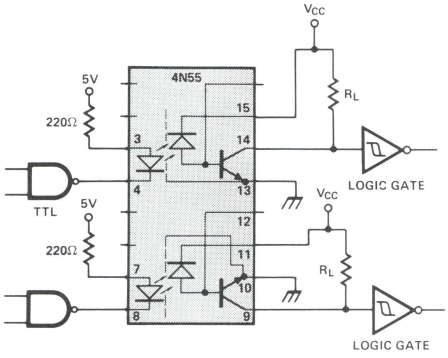


Figure 10. Test Circuit for Transient Immunity and Typical Waveforms.

OPTOCOUPLERS

HERMETIC OPTOCOUPLERS

*JEDEC Registered Data



LOGIC FAMILY	LSTTL	CMOS	
DEVICE NO.	54LS14	CD40106BM	
Vcc	5V	5V	15V
RL 5% TOLERANCE	*18kΩ	8.2kΩ	22kΩ

*THE EQUIVALENT OUTPUT LOAD RESISTANCE IS AFFECTED BY THE LSTTL INPUT CURRENT AND IS APPROXIMATELY 8.2kΩ.

This is a worst case design which takes into account 25% degradation of CTR. See App. Note 1002 to assess actual degradation and lifetime.

Figure 11. Recommended Logic Interface.

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's 883B optocouplers are in compliance with MIL-STD-883, Revision C. Deviations listed below are specifically allowed in DESC drawing 81028 for an H.P. Optocoupler from the same generic family using the same manufacturing process, design rules and elements of the same microcircuit group.

Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005 of MIL-STD-883. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

4N55/883B Clarifications:

I. 100% screening per MIL-STD-883, Method 5004 constant acceleration — condition A not E.

II. Quality Conformance Inspection per MIL-STD-883, Method 5005, Group A, B, C and D.

Group A — See table below for specific electrical tests.
Group B — No change
Group C — Constant Acceleration — Condition A not E.
Group D — Constant Acceleration — Condition A not E.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
4N55	4N55/883B

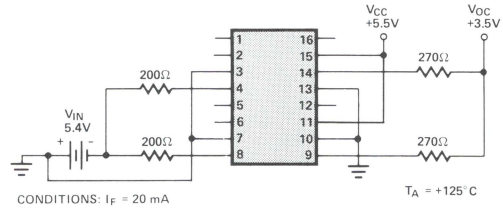


Figure 12. Operating Circuit for Burn-in and Steady State Life Tests

GROUP A — ELECTRICAL TESTS

QUANTITY/ACCEPT NO. = 116/0

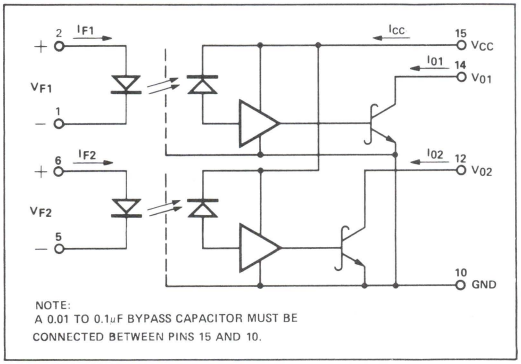
Subgroup 1 * Static tests at $T_A = 25°C$, I_{OH}, BV_R, I_{CCL}, I_{CCH}, CTR, V_F, I_{OH1} and I_{I-O}.
Subgroup 2 * Static tests at $T_A = +125°C$, I_{OH}, BV_R I_{CCL}, I_{CCH}, CTR, V_F and I_{OH1}
Subgroup 3 * Static tests at $T_A = -55°C$, I_{OH}, BV_R I_{CCL}, I_{CCH}, CTR, V_F and I_{OH1}
Subgroup 4, 5, 6, 7, 8A and 8B These subgroups are non-applicable to this device type
Subgroup 9 * Switching tests at $T_A = 25°C$, t_{PLH} and t_{PHL}
Subgroup 10 * Switching tests at $T_A = +125°C$, t_{PLH} and t_{PHL}
Subgroup 11 * Switching tests at $T_A = -55°C$, t_{PLH} and t_{PHL}

* Limits and Conditions per Table II.

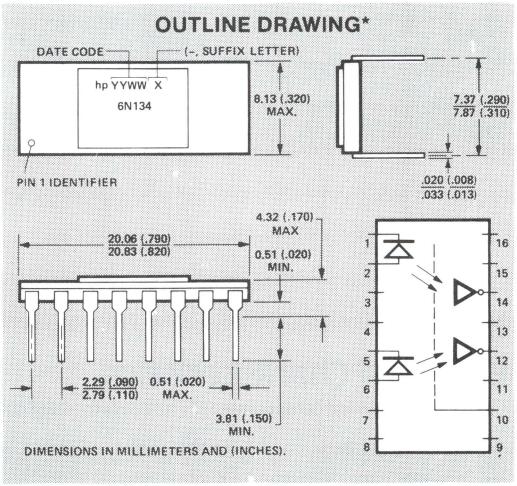
HEWLETT PACKARD

DUAL CHANNEL HIGH CMR HIGH SPEED HERMETICALLY SEALED OPTOCOUPLER

6N134



NOTE:
A 0.01 TO 0.1μF BYPASS CAPACITOR MUST BE CONNECTED BETWEEN PINS 15 AND 10.



Features

- NEW — MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- PERFORMANCE GUARANTEED OVER -55°C TO +125°C AMBIENT TEMPERATURE RANGE
- HERMETICALLY SEALED
- HIGH SPEED
- NEW — INTERNAL SHIELD FOR HIGHER CMR
- TTL COMPATIBLE INPUT AND OUTPUT
- HIGH COMMON MODE REJECTION
- DUAL-IN-LINE PACKAGE
- 1500 VDC WITHSTAND TEST VOLTAGE
- EIA REGISTRATION
- HIGH RADIATION IMMUNITY
- HCPL-2631 FUNCTION COMPATIBILITY

Applications

- LOGIC GROUND ISOLATION
- LINE RECEIVER
- COMPUTER — PERIPHERAL INTERFACE
- VEHICLE COMMAND/CONTROL ISOLATION
- HARSH INDUSTRIAL ENVIRONMENTS
- SYSTEM TEST EQUIPMENT ISOLATION

Description

The 6N134 consists of a pair of inverting optically coupled gates, each with a light emitting diode and a unique high gain integrated photon detector in a hermetically sealed ceramic package. The output of the detector is an open collector Schottky clamped transistor. Internal shields provide a guaranteed common mode transient immunity specification of 1000 V/μs.

This unique dual coupler design provides maximum DC and AC circuit isolation between each input and output while achieving TTL circuit compatibility. The isolator operational parameters are guaranteed from -55° C to +125° C, such that a minimum input current of 10 mA in each channel will sink a six gate fanout (10 mA) at the output with 4.5 to 5.5 V V_{CC} applied to the detector. This isolation and coupling is achieved with a typical propagation delay of 55 nsec.

Hewlett-Packard's high reliability part type 8102801EC meets Class B testing requirements of MIL-STD-883. This part is the recommended and preferred device from the 6N134 product family for use in high reliability applications. Details of the 8102801EC test program may be seen in the data sheet for this part.

See the selection guide at the front of this section for other devices in this family.

*JEDEC Registered Data

Recommended Operating Conditions

TABLE I

	Sym.	Min.	Max.	Units
Input Current, Low Level Each Channel	I_{FL}	0	250	μA
Input Current, High Level, Each Channel	I_{FH}	12.5†	20	mA
Supply Voltage	V_{CC}	4.5	5.5	V
Fan Out (TTL Load) Each Channel	N		6	
Operating Temperature	T_A	-55	125	°C

Absolute Maximum Ratings*

(No derating required up to 125° C)

Storage Temperature ..... -65° C to +150° C
Operating Temperature ..... -55° C to +125° C
Lead Solder Temperature ..... 260° C for 10 s
(1.6 mm below seating plane)

Peak Forward Input
Current (each channel) ..... 40 mA (≤1 ms Duration)
Average Input Forward Current (each channel) ... 20 mA
Input Power Dissipation (each channel) ..... 35 mW
Reverse Input Voltage (each channel) ..... 5 V
Supply Voltage — V_{CC} ..... 7 V (1 minute maximum)
Output Current — I_O (each channel) ..... 25 mA
Output Power Dissipation (each channel) ..... 40 mW
Output Voltage — V_O (each channel) ..... 7 V
Total Power Dissipation (both channels) ..... 350 mW

†12.5 mA condition permits at least 20% CTR degradation guardband. Initial switching threshold is 10 mA or less.

TABLE II

Electrical Characteristics

Over Recommended Temperature (T_A = -55° C to +125° C) Unless Otherwise Noted

Parameter	Symbol	Min.	Typ.**	Max.	Units	Test Conditions	Figure	Note
High Level Output Current	I_{OH}*		5	250	μA	V_{CC} = 5.5 V, V_O = 5.5 V, I_F = 250 μA		1
Low Level Output Voltage	V_{OL}*		0.4	0.6	V	V_{CC} = 5.5 V, I_F = 10 mA, I_{OL} (Sinking) = 10 mA	4	1, 9
High Level Supply Current	I_{CCH}*		18	28	mA	V_{CC} = 5.5 V, I_F = 0 (Both Channels)		
Low Level Supply Current	I_{CCL}*		26	36	mA	V_{CC} = 5.5 V, I_F = 20 mA (Both Channels)		
Input Forward Voltage	V_F*		1.5	1.75	V	I_F = 20 mA, T_A = 25° C	1	1
	V_F			1.85	V	I_F = 20 mA	1	1
Input Reverse Breakdown Voltage	BV_R*	5			V	I_R = 10 μA, T_A = 25° C		1
Input-Output Insulation Leakage Current	I_{I-O}*			1.0	μA	V_{I-O} = 1500 Vdc, Relative Humidity = 45%, T_A = 25° C, t = 5 s		2, 10
Propagation Delay Time to	t_{PLH}*		60	90	ns	C_L = 15 pF, R_L = 510 Ω	2, 3	1, 5
High Output Level	t_{PLH}			100		C_L = 50 pF, I_F = 13 mA, T_A = 25° C		
Propagation Delay Time to	t_{PHL}*		55	90	ns	C_L = 15 pF, R_L = 510 Ω	2, 3	1, 6
Low Output Level	t_{PHL}			100		C_L = 50 pF, I_F = 13 mA, T_A = 25° C		
Common Mode Transient Immunity at High Output Level	$\|CM_H\|$	1000	10000		V/μs	V_{CM} = 50 V (peak), V_O (min.) = 2 V, R_L = 510Ω, I_F = 0 mA	6	1, 7
Common Mode Transient Immunity at Low Output Level	$\|CM_L\|$	1000	10000		V/μs	V_{CM} = 50 V (peak), V_O (max.) = 0.8 V, R_L = 510Ω, I_F = 10 mA	6	1, 8

*JEDEC Registered Data

**All typical values are at V_{CC} = 5 V, T_A = 25° C

TABLE III

Typical Characteristics at $T_A = 25°C$, $V_{CC} = 5\ V$

EACH CHANNEL

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Figure	Note
Input Capacitance	C_{IN}		60		pF	$V_F = 0$, f = 1 MHz		1
Input Diode Temperature Coefficient	$\frac{\Delta V_F}{\Delta T_A}$		-1.5		mV/°C	$I_F = 20$ mA		1
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	$V_{I-O} = 500$ V		3
Capacitance (Input-Output)	C_{I-O}		1.7		pF	f = 1 MHz		3
Input-Input Leakage Current	I_{I-I}		0.5		nA	Relative Humidity = 45% $V_{I-I} = 500$ V, t = 5s		4
Resistance (Input-Input)	R_{I-I}		10^{12}		Ω	$V_{I-I} = 500$ V		4
Capacitance (Input-Input)	C_{I-I}		0.55		pF	f = 1 MHz		4
Output Rise Time (10-90%)	t_r		35		ns	$R_L = 510\ \Omega$, $C_L = 15$ pF		1
Output Fall Time (90-10%)	t_f		35		ns	$I_F = 13$ mA		1

NOTES:

1. Each channel.
2. Measured between pins 1 through 8 shorted together and pins 9 through 16 shorted together.
3. Measured between pins 1 and 2 or 5 and 6 shorted together, and pins 10, 12, 14 and 15 shorted together.
4. Measured between pins 1 and 2 shorted together, and pins 5 and 6 shorted together.
5. The t_{PLH} propagation delay is measured from the 6.5 mA point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
6. The t_{PHL} propagation delay is measured from the 6.5 mA point on the leading edge of the input pulse to the 1.5 V point on the leading edge of the output pulse.
7. CM_H is the max. tolerable common mode transient to assure that the output will remain in a high logic state (i.e., $V_O > 2.0$ V).
8. CM_L is the max. tolerable common mode transient to assure that the output will remain in a low logic state (i.e., $V_O < 0.8$ V).
9. It is essential that a bypass capacitor (.01 to 0.1 μF, ceramic) be connected from pin 10 to pin 15. Total lead length between both ends of the capacitor and the isolator pins should not exceed 20 mm.
10. This is a momentary withstand test, not an operating condition.

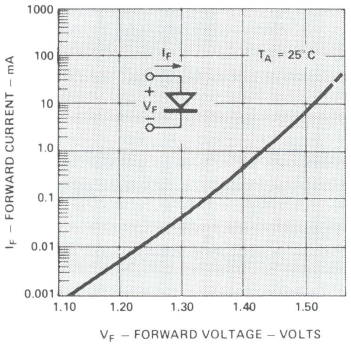


Figure 1. Input Diode Forward Characteristic

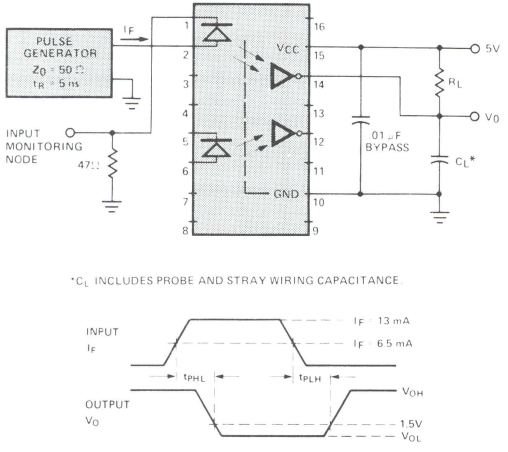


Figure 2. Test Circuit for t_{PHL} and t_{PLH}*

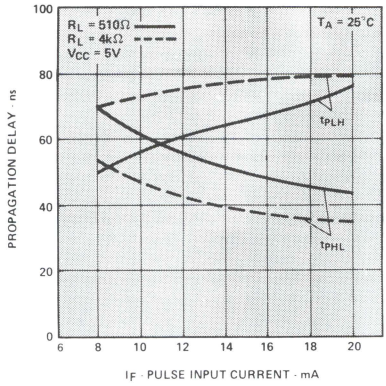


Figure 3. Propagation Delay, t_{PHL} and t_{PLH} vs. Pulse Input Current, I_{FH}

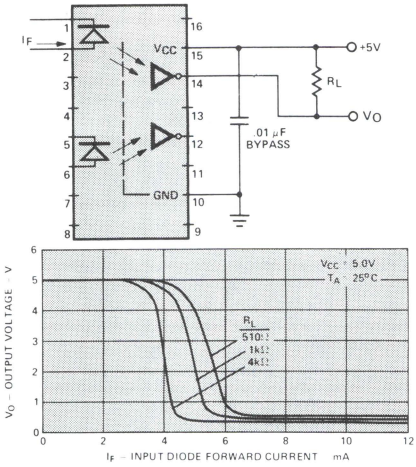


Figure 4. Input-Output Characteristics

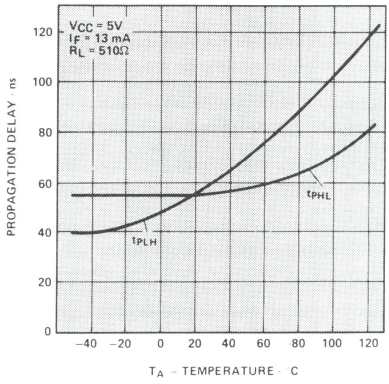


Figure 5. Propagation Delay vs. Temperature

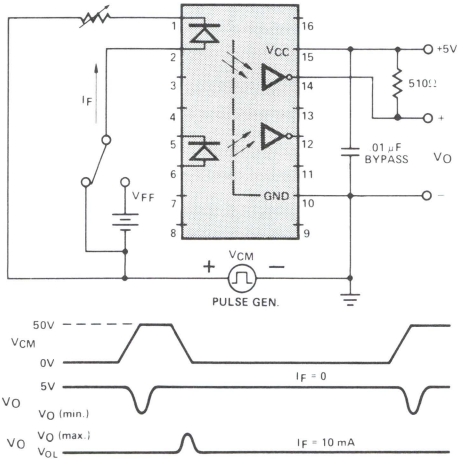


Figure 6. Typical Common Mode Rejection Characteristics/Circuit

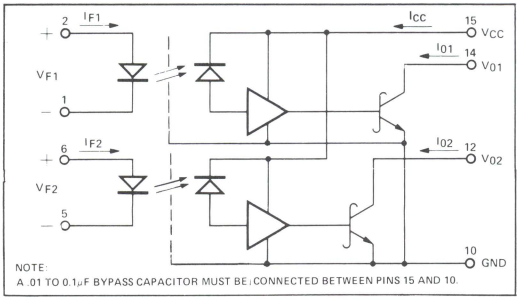
*JEDEC Registered Data

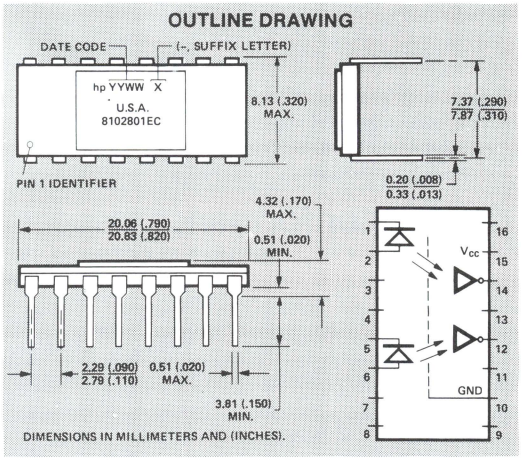
HEWLETT PACKARD

DUAL CHANNEL HIGH CMR HIGH SPEED HERMETICALLY SEALED OPTOCOUPLER

DESC APPROVED

8102801EC





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- RECOGNIZED BY DESC*
- HERMETICALLY SEALED
- MIL-STD-883 CLASS B TESTING
- HIGH SPEED
- NEW—INTERNAL SHIELD FOR HIGHER CMR
- PERFORMANCE GUARANTEED OVER -55° C TO +125° C AMBIENT TEMPERATURE RANGE
- TTL COMPATIBLE INPUT AND OUTPUT
- DUAL-IN-LINE PACKAGE
- 1500 VDC WITHSTAND TEST VOLTAGE
- HIGH RADIATION IMMUNITY

Applications

- MILITARY/HIGH RELIABILITY SYSTEM
- LOGIC GROUND ISOLATION
- LINE RECEIVER
- COMPUTER—PERIPHERAL INTERFACE
- VEHICLE COMMAND/CONTROL ISOLATION
- SYSTEM TEST EQUIPMENT ISOLATION

Description

The 8102801EC is the DESC selected item drawing assigned by DOD for the 6N134 optocoupler which is in accordance with MIL-STD-883 class B testing. Operating characteristic curves for this part can be seen in the 6N134 data sheet.

The 810280EC consists of a pair of inverting optically coupled gates, each with a light emitting diode and a unique high gain integrated photon detector in a hermetically sealed ceramic package. The output of the detector is an open collector Schottky clamped transistor. Internal shields provide a guaranteed common mode transient immunity specification of 1000 V/μs.

This unique dual coupler design provides maximum DC and AC circuit isolation between each input and output while achieving TTL circuit compatibility. The isolator operational parameters are guaranteed from -55° C to +125° C, such that a minimum input current of 10 mA in each channel will sink a six gate fanout (10 mA) at the output with 4.5 to 5.5 V V_{CC} applied to the detector. This isolation and coupling is achieved with a typical propagation delay of 55 nsec.

The photo ICs used in this device are less susceptible to radiation damage than PIN photo diodes or photo transistors due to their relatively thinner photo region.

The test program performed on the 8102801EC is in compliance with DESC drawing 81028 and the provisions of Method 5008, Class B of MIL-STD-883.

Recommended Operating Conditions

Supply Voltage	4.5 V dc minimum to 5.5 V dc maximum
High Level Input Current[1]	12.5 mA dc minimum (each channel)
Low Level Input Current	250 μA dc maximum (each channel)
Normalized Fanout (TTL Load)	6 maximum (each channel)
Operating Temperature Range	-55° C to +125° C

1. This condition permits at least 20 percent h_F (CTR) degradation. The initial switching threshold is 10 mA dc or less.

Absolute Maximum Ratings

Supply Voltage Range	7 V (1 minute maximum)
Input Current (each channel)	20 mA dc
Storage Temperature Range	-65° C to +150° C
Maximum Power Dissipation (both channels)	350 mW
Lead Temperature (soldering 10 seconds)	300° C for 10 seconds (1.6 mm below seating plane)
Junction Temperature (T_J)	175° C

*Defense Electronic Supply Center (DESC) is an agency of the Department of Defense (DOD).

100% Screening

MIL-STD-883, METHOD 5004 (CLASS B DEVICES)

Test Screen	Method	Conditions
1. Precap Internal Visual	2017	
2. High Temperature Storage	1008	Condition C, T_A= 150°C, Time = 24 hours minimum
3. Temperature Cycling	1010	Condition C, -65°C to +150°C, 10 cycles
4. Constant Acceleration	2001	Condition A, 5KG's, Y_1 and Y_2 axis only
5. Fine Leak	1014	Condition A
6. Gross Leak	1014	Condition C
7. Interim Electrical Test	—	Optional
8. Burn-In	1015	Condition B, Time = 160 hours minimum T_A = +125°C, V_{CC} = 5.5V, I_F = 20 mA, I_O = 25 mA (Figure 1)
9. Final Electrical Test Electrical Test	— —	Group A, Subgroup 1, 5% PDA applies Group A, Subgroup 2, 3, 9
10. External Visual	2009	

Quality Conformance Inspection

GROUP A ELECTRICAL PERFORMANCE CHARACTERISTICS

QUANTITY/ACCEPT NO. = 116/0

Test	Symbol	Conditions	Group A Subgroups[6]	Limits Min.	Limits Max.	Unit
Low Level Output Voltage	V_{OL}	V_{CC} = 5.5 V; I_F = 10 mA[1]; I_{OL} = 10 mA	1, 2, 3	—	0.6	V
Current Transfer Ratio	h_F (CTR)	V_O = 0.6 V; I_F = 10 mA;[1] V_{CC} = 5.5 V	1, 2, 3	100	—	%
High Level Output Current	I_{OH}	V_{CC} = 5.5 V; V_O = 5.5 V[1]; I_F = 250 μA	1, 2, 3	—	250	μA dc
High Level Supply Current	I_{CCH}	V_{CC} = 5.5 V; I_{F1} = I_{F2} = 0 mA	1, 2, 3	—	28	mA dc
Low Level Supply Current	I_{CCL}	V_{CC} = 5.5 V; I_{F1} = I_{F2} = 20 mA	1, 2, 3	—	36	mA dc
Input Forward Voltage	V_F	I_F = 20 mA[1]	1, 2	—	1.75	V dc
			3	—	1.85	
Input Reverse Breakdown Voltage	V_{BR}	I_R = 10 μA[1]	1, 2, 3	5.0	—	V dc
Input to Output Insulation Leakage Current	I_{I-O}	V_{IO} = 1500 V dc[2]; Relative Humidity = 45 percent t = 5 seconds	1	—	1.0	μA dc
Capacitance Between Input/Output	C_{I-O}	f = 1 MHz; T_C = 25°C[3]	4	—	4.0	pF
Propagation Delay Time, Low to High Output Level	t_{PLH}	R_L = 510 Ω; C_L = 50 pF[1, 4]; I_F = 13 mA	9	—	100	ns
			10, 11	—	140	
Propagation Delay Time, High to Low Output Level	t_{PHL}	R_L = 510 Ω; C_L = 50 pF[1, 5]; I_F = 13 mA	9	—	100	ns
			10, 11	—	120	
Output Rise Time	t_{LH}	R_L = 510 Ω[1]; C_L = 50 pF; I_F = 13 mA	9, 10, 11	—	90	ns
Output Fall Time	t_{HL}			—	40	
Common Mode Transient Immunity at High Output Level	$\|CM_H\|$	V_{CM} = 50 V (peak);[1, 8] V_O = 2 V (minimum); R_L = 510 Ω; I_F = 0 mA	9, 10, 11	1000	—	V/μs
Common Mode Transient Immunity at Low Output Level	$\|CM_L\|$	V_{CM} = 50 V (peak);[1, 8] V_O = 0.8 V (maximum); R_L = 510 Ω; I_F = 10 mA	9, 10, 11	1000	—	V/μs

See notes on following page.

Notes: 1. Each channel.
2. Measured between pins 1 through 8 shorted together and pins 9 through 16 shorted together.
3. Measured between input pins 1 and 2, or 5 and 6 shorted together and output pins 10, 12, 14 and 15 shorted together.
4. The t_{PLH} propagation delay is measured from the 6.5 mA point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
5. The t_{PHL} propagation delay is measured from the 6.5 mA point on the leading edge of the input pulse to the 1.5 V point on the leading edge of the output pulse.
6. Conditions of Group A subgroups may be seen in the High Reliability section of this catalog.
7. This is a momentary withstand test, not an operating condition.
8. The DESC drawing for this part guarantees a minimum CM_H and CM_L of 40 V/μs and -60 V/μs respectively at V_{CM} = 10 V (peak). HP's CMR testing exceeds these requirements.

GROUP B TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)

Test	Method	Conditions	LTPD
Subgroup 1 Physical Dimensions (Not required if Group D is to be performed)	2016		2 Devices (0 failures)
Subgroup 2 Resistance to Solvents	2015		4 Devices (0 failures)
Subgroup 3 Solderability (LTPD applies to number of leads inspected — no fewer than 3 devices shall be used).	2003	Soldering Temperature of 245 ± 5° C for 10 seconds	10 (3 Devices)
Subgroup 4 Internal Visual and Mechanical	2014		1 Device (0 failures)
Subgroup 5 Bond Strength Thermocompression: (Performed at precap, prior to seal LTPD applies to number of bond).	2011	Test Condition D	15
Subgroup 6 Internal Water Vapor Content (Not applicable — does not contain desiccant)	—		—
Subgroup 7* Electrical Test Electrostatic Discharge Sensitivity Electrical Test *(To be performed at initial qualification only)	3015	Group A, and Delta Limits in Accordance with Method 3015 Group A, and Delta Limits in Accordance with Method 3015	3(0) with repeat for cumulative effects 15(0)

GROUP C TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)

Test	Method	Conditions	LTPD
Subgroup 1 Steady State Life Test	1005	Condition B, Time = 1000 hours total T_A = +125° C, V_{CC} = 5.5 V, I_F = 20 mA, I_O = 25 mA (Figure 1)	5
Endpoint Electricals at 1000 hours		Group A, Subgroup 1, 2, 3	
Subgroup 2 Temperature Cycling	1010	Condition C, -65° C to +150° C, 10 cycles	15
Constant Acceleration	2001	Condition A, 5KGs, Y_1 and Y_2 axis only	
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1010	Per Visual Criteria of Method 1010	
Endpoint Electricals		Group A, Subgroup 1, 2, 3	

GROUP D TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)

Test	Method	Conditions	LTPD
Subgroup 1			
Physical Dimensions	2016		15
Subgroup 2			
Lead Integrity	2004	Test Condition B2 (lead fatigue)	15
Subgroup 3			
Thermal Shock	1011	Condition B, (-55°C to +125°C) 15 cycles min.	15
Temperature Cycling	1010	Condition C, (-65°C to +150°C) 100 cycles min.	
Moisture Resistance	1004		
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination		Per Visual Criteria of Method 1004 & 1010	
Endpoint Electricals		Group A, Subgroup 1, 2, 3	
Subgroup 4			
Mechanical Shock	2002	Condition B, 1500G, t = 0.5 ms, 5 blows in each orientation	15
Vibration Variable Frequency	2007	Condition A	
Constant Acceleration	2001	Condition A, 5KGs, Y_1 and Y_2 axis only	
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1010	Per Visual Criteria of Method 1010	
Endpoint Electricals		Group A, Subgroup 1, 2, 3	
Subgroup 5			
Salt Atmosphere	1009	Condition A min.	15
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1009	Per Visual Criteria of Method 1009	
Subgroup 6			
Internal Water Vapor Content	1018	5000 ppm maximum water content at 100°C.	3 Devices (0 failures) 5 Devices (1 failure)
Subgroup 7			
Adhesion of Lead Finish	2025		15
Subgroup 8			
Lid Torque (not applicable — solder seal)	2024		5 Devices (0 failures)

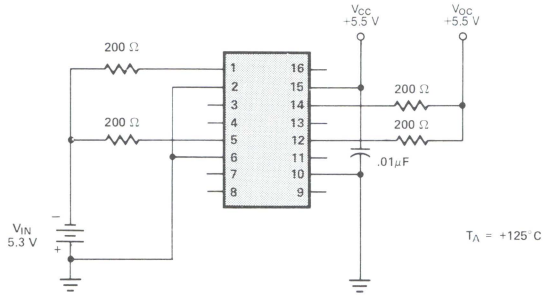
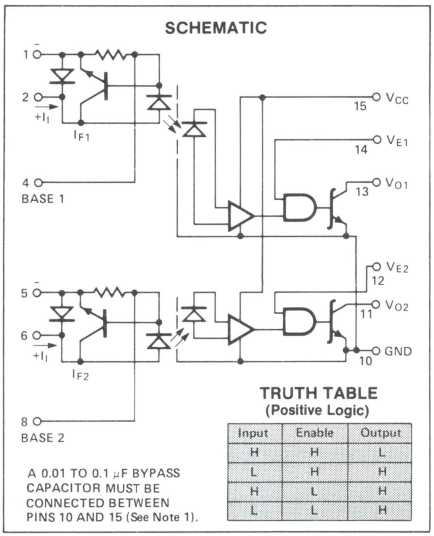


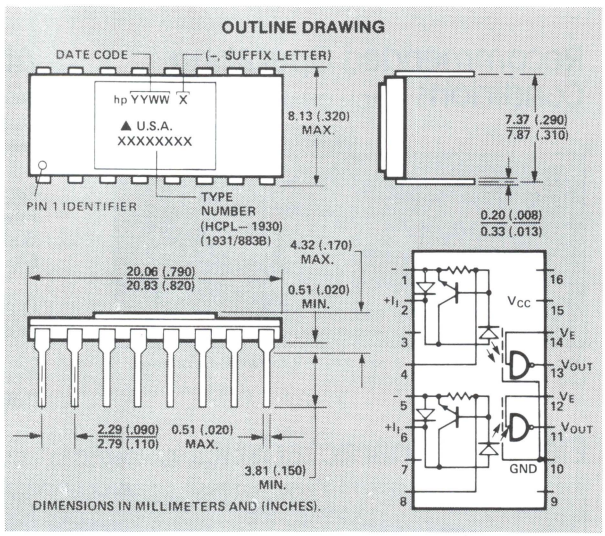
Figure 1. Operating Circuit for Burn-in and Steady State Life Tests.

HEWLETT PACKARD

DUAL CHANNEL LINE RECEIVER HERMETIC OPTOCOUPLER

HCPL-1930
HCPL-1931
(883B)





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- HERMETICALLY SEALED
- MIL-STD-883 CLASS B TESTING
- HIGH SPEED — 10Mb/s
- PERFORMANCE GUARANTEED OVER -55° C TO +125° C AMBIENT TEMPERATURE RANGE
- ACCEPTS A BROAD RANGE OF DRIVE CONDITIONS
- ADAPTIVE LINE TERMINATION INCLUDED
- INTERNAL SHIELD PROVIDES EXCELLENT COMMON MODE REJECTION
- EXTERNAL BASE LEAD ALLOWS "LED PEAKING" AND LED CURRENT ADJUSTMENT
- 1500 Vdc WITHSTAND TEST VOLTAGE
- HIGH RADIATION IMMUNITY
- HCPL-2602 FUNCTION COMPATIBILITY

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- ISOLATED LINE RECEIVER
- SIMPLEX/MULTIPLEX DATA TRANSMISSION
- COMPUTER-PERIPHERAL INTERFACE
- MICROPROCESSOR SYSTEM INTERFACE
- DIGITAL ISOLATION FOR A/D, D/A CONVERSION
- CURRENT SENSING
- INSTRUMENT INPUT/OUTPUT ISOLATION
- GROUND LOOP ELIMINATION
- PULSE TRANSFORMER REPLACEMENT

Description

The HCPL-1930 and HCPL-1931 units are dual channel, hermetically sealed, high CMR, line receiver optocouplers. The products are capable of operation and storage over the full military temperature range and can be purchased as either a standard product (HCPL-1930) or with full MIL-STD-883 Class Level B testing (HCPL-1931). Both products are in sixteen pin hermetic dual in-line packages.

Each unit contains two independent channels, consisting of a GaAsP light emitting diode, an input current regulator, and an integrated high gain photon detector. The input regulator serves as a line termination for line receiver applications. It clamps the line voltage and regulates the LED current so line reflections do not interfere with circuit performance.

(Continued on next page)

The regulator allows a typical LED current of 12.5 mA before it starts to shunt excess current. The output of the detector IC is an open collector Schottky clamped transistor. An enable input gates the detector. The internal detector shield provides a guaranteed common mode transient immunity specification of ±1000 V/μsec.

DC specifications are compatible with TTL logic and are guaranteed from -55°C to +125°C allowing trouble free interfacing with digital logic circuits. An input current of 10 mA will sink a six gate fan-out (TTL) at the output with a typical propagation delay from input to output of only 45nsec.

CAUTION: The small junction sizes inherent to the design of this bipolar component increases the component's susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD.

Recommended Operating Conditions (EACH CHANNEL)

	Sym.	Min.	Max.	Units
Input Current, Low Level	I_{IL}	0	250	μA
Input Current, High Level*	I_{IH}	12.5	60	mA
Supply Voltage, Output	V_{CC}	4.5	5.5	V
High Level Enable Voltage	V_{EH}	3.0	V_{CC}	V
Low Level Enable Voltage	V_{EL}	0	0.8	V
Fan Out (TTL Load)	N		6	
Operating Temperature	T_A	-55	125	°C

*12.5 mA condition permits at least 20% CTR degradation guardband. Initial switching threshold is 10mA or less.

Absolute Maximum Ratings

Storage Temperature ..... -65°C to +150°C
Operating Temperature ..... -55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 s
(1.6mm below seating plane)
Forward Input Current—I_I (Each Channel) ..... 60 mA[2]
Reverse Input Current ..... 60 mA
Supply Voltage — V_{CC} ..... 7V (1 Minute Maximum)
Enable Input Voltage — V_E (Each Channel) ..... 5.5 V
(Not to exceed V_{CC} by more than 500 mV)
Output Collector Current — I_O (Each Channel) .... 25 mA
Output Collector Power Dissipation (Each Channel). 40 mW
Output Collector Voltage — V_O (Each Channel) ..... 7 V
Total Package Power Dissipation ..... 564 mW
Total Input Power Dissipation (Each Channel) ... 168 mW

Electrical Characteristics T_A = -55°C to +125°C, unless otherwise specified

Parameter	Symbol	Min.	Typ*	Max.	Units	Test Conditions	Figure	Note
High Level Output Current	I_{OH}		20	250	μA	V_{CC} = 5.5V, V_O = 5.5V, I_I = 250μA, V_E = 3.0V	3	3
Low Level Output Voltage	V_{OL}		0.3	0.6	V	V_{CC} = 5.5V, I_I = 10mA, V_E = 3.0V, I_{OL} (Sinking) = 10 mA	1	3
Input Voltage	V_I		2.2	2.6	V	I_I = 10 mA	2	3
			2.35	2.75		I_I = 60mA	2	3
Input Reverse Voltage	V_R		0.8	1.10	V	I_R = 10mA		3
Low Level Enable Current	I_{EL}		-1.45	-2.0	mA	V_{CC} = 5.5V, V_E = 0.5V		3
High Level Enable Voltage	V_{EH}	2.0			V			3, 12
Low level Enable Voltage	V_{EL}			0.8	V			3
High Level Supply Current	I_{CCH}		21	28	mA	V_{CC} = 5.5V, I_I = 0, V_E = 0.5V both channels		
Low Level Supply Current	I_{CCL}		27	36	mA	V_{CC} = 5.5V, I_I = 60 mA, V_E = 0.5V both channels		
Input-Output Insulation Leakage Current	I_{I-O}			1	μA	Relative Humidity=45%, T_A = 25°C, t = 5 s, V_{I-O} = 1500 Vdc		4
Propagation Delay Time to High Output Level	t_{PLH}		45		ns	C_L = 15pF	5	3, 5
			55	100		C_L = 50pF; R_L = 510Ω, I_I=13mA, T_A = 25°C		
Propagation Delay Time to Low Output Level	t_{PHL}		55		ns	C_L = 15pF	5	3, 6
			60	100		C_L = 50pF		
Common Mode Transient Immunity at High Output Level	$\|CM_H\|$	1000	10,000		V/μs	V_{CM} = 50 V (peak), V_O (min.)=2 V, T_A=25°C, R_L = 510Ω, I_I = 0 mA	7	3, 9
Common Mode Transient Immunity at Low Output Level	$\|CM_L\|$	1000	10,000		V/μs	V_{CM} = 50 V (peak) V_O (max.) = 0.8 V, T_A=25°C, R_L = 510Ω, I_I = 10 mA	7	3, 10

*All typical values are at V_{CC} = 5V, T_A = 25°C.

Typical Characteristics $T_A = 25°C$, $V_{CC} = 5$ V

Parameter	Symbol	Typ.	Units	Test Conditions	Fig.	Note
Resistance (Input-Output)	R_{I-O}	10^{12}	Ω	$V_{I-O} = 500$ Vdc		3, 13
Capacitance (Input-Output)	C_{I-O}	1.7	pF	f = 1 MHz		3, 13
Input-Input Insulation Leakage Current	I_{I-I}	0.5	nA	45% Relative Humidity, V_{I-I}=500 Vdc t = 5s.		11
Resistance (Input-Input)	R_{I-I}	10^{12}	Ω	$V_{I-I} = 500$ Vdc		11
Capacitance (Input-Input)	C_{I-I}	.55	pF	f = 1 MHz		11
Propagation Delay Time of Enable from V_{EH} to V_{EL}	t_{ELH}	35	ns	$R_L = 510\Omega$, $C_L = 15$pF, $I_I = 13$ mA, $V_{EH} = 3$ V, $V_{EL} = 0$ V	6,7	3, 7
Propagation Delay Time of Enable from V_{EL} to V_{EH}	t_{EHL}	35	ns		6,7	3, 8
Output Rise Time (10-90%)	t_r	30	ns	$R_L = 510\Omega$, $C_L = 15$pF, $I_I = 13$ mA		3
Output Fall Time (90-10%)	t_f	24	ns			3
Input Capacitance	C_I	60	pF	f=1 MHz, V_I=0, PINS 1 to 2 or 5 to 6		3

NOTES:

1. Bypassing of the power supply line is required, with a 0.01 μF ceramic disc capacitor adjacent to each isolator. The power supply bus for the isolator(s) should be separate from the bus for any active loads, otherwise a larger value of bypass capacitor (up to 0.1 μF) may be needed to suppress regenerative feedback via the power supply.
2. Derate linearly at 1.2 mA/°C above $T_A = 100°C$.
3. Each channel.
4. Device considered a two terminal device: pins 1 through 8 are shorted together, and pins 9 through 16 are shorted together.
5. The t_{PLH} propagation delay is measured from the 6.5 mA point on the trailing edge of the input pulse to the 1.5 V point on the trailing edge of the output pulse.
6. The t_{PLH} propagation delay is measured from the 6.5 mA point on the leading edge of the input pulse to the 1.5V point on the leading edge of the output pulse.
7. The t_{ELH} enable propagation delay is measured from the 1.5 V point on the trailing edge of the enable input pulse to the 1.5 V point on the trailing edge of the output pulse.
8. The t_{EHL} enable propagation delay is measured from the 1.5 V point on the leading edge of the enable input pulse to the 1.5 V point on the leading edge of the output pulse.
9. CM_H is the maximum tolerable rate of rise of the common mode voltage to assure that the output will remain in a high logic state (i.e. $V_{OUT} > 2.0$ V).
10. CM_L is the maximum tolerable rate of fall of the common mode voltage to assure that the output will remain in a low logic state (i.e. $V_{OUT} < 0.8$ V).
11. Measured between adjacent input leads shorted together, i.e. between 1, 2 and 4 shorted together and pins 5, 6 and 8 shorted together.
12. No external pull up is required for a high logic state on the enable input.
13. Measured between pins 1 and 2 or 5 and 6 shorted together, with pins 10 through 15 shorted together.

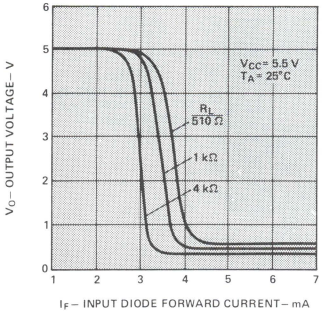


Figure 1. Input-Output Characteristics

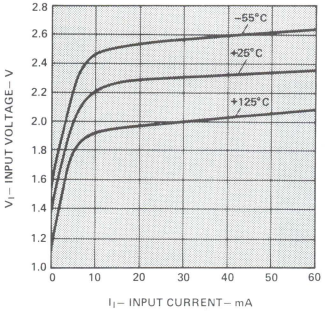


Figure 2. Input Characteristics.

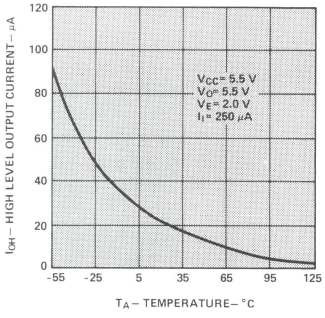


Figure 3. High Level Output Current vs. Temperature.

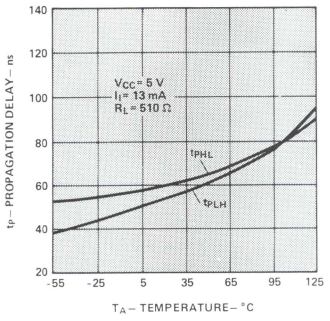


Figure 4. Propagation Delay vs. Temperature.

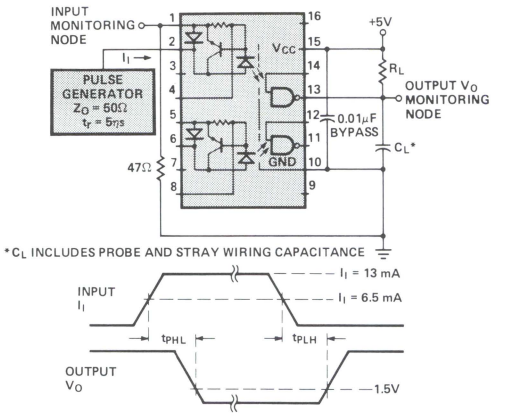


Figure 5. Test Circuit for t_{PHL} and t_{PLH}.

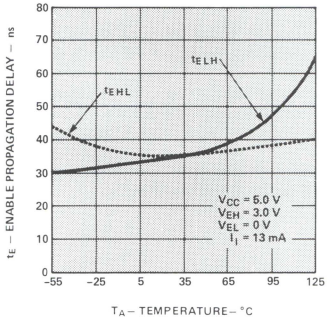


Figure 6. Enable Propagation Delay vs. Temperature

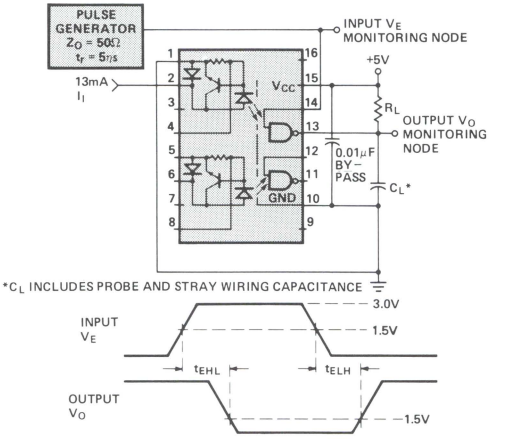


Figure 7. Test Circuit for t_{EHL} and t_{ELH}.

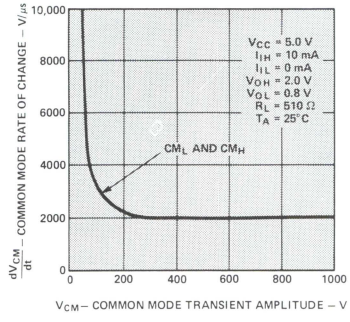


Figure 8. Typical Common Mode Transient Immunity

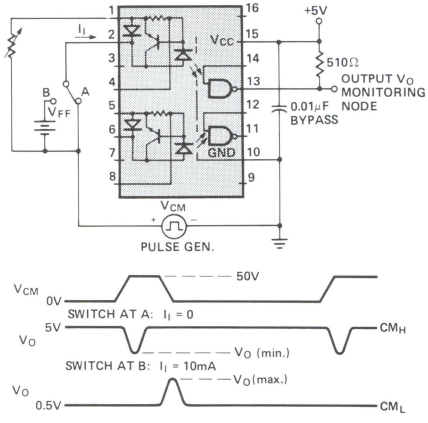


Figure 9. Test Circuit for Common Mode Transient Immunity and Typical Waveforms

PART NUMBERING SYSTEM

Commercial Product	Class B Product
HCPL-1930	HCPL-1931

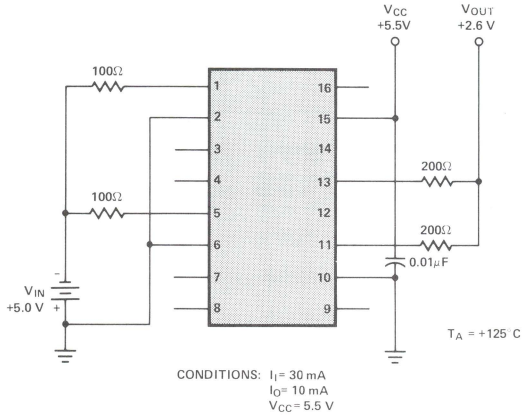


Figure 10. Burn In Circuit

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett-Packard's 883B Optocouplers are in compliance with MIL-STD-883, Revision C. Deviations listed below are specifically allowed in DESC drawing 81028 for an H.P. Optocoupler from the same generic family using the same manufacturing process, design rules and elements of the same microcircuit group.

Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005 of MIL-STD-883. Details of this test program may be found in the High Reliability section of the Optoelectronics Designer's Catalog.

HCPL-1931 Clarifications:

I. 100% screening per MIL-STD-883, Method 5004 constant acceleration — Condition A not E.

II. Quality Conformance Inspection per MIL-STD-883, Method 5005, Group A, B, C, and D.
Group A — See table on next page for specific electrical tests.
Group B — No change.
Group C — Constant Acceleration — Condition A not E.
Group D — Constant Acceleration — Condition A not E.

GROUP A

QUANTITY/ACCEPT NO. = 116/0

Subgroup 1
*Static tests at $T_A = 25°C$ — I_{OH}, V_{OL}, V_I, I_{CCH}, I_{CCL}, I_{EL}, V_{EH}, V_{EL}, V_R, I_{I-O}

Subgroup 2
*Static tests at $T_A = +125°C$ — I_{OH}, V_{OL}, V_I, I_{CCH}, I_{CCL}, I_{EL}, V_{EH}, V_{EL}, V_R

Subgroup 3
*Static tests at $T_A = -55°C$ — I_{OH}, V_{OL}, V_I, I_{CCH}, I_{CCL}, I_{EL}, V_{EH}, V_{EL}, V_R

Subgroup 4, 5, 6, 7, 8A & 8B — These subgroups are non-applicable to this device type.

Subgroup 9
*Switching tests at $T_A = 25°C$ — t_{PLH}, t_{PHL}, CM_H and CM_L

Subgroup 10
Switching tests at $T_A = +125°C$

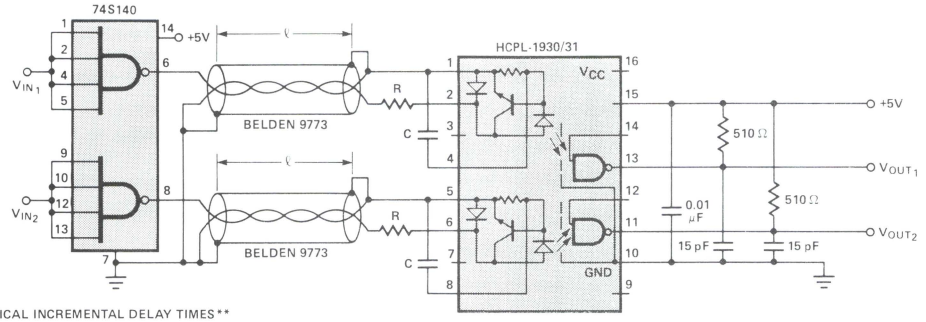
Symbol	Max.	Units	Test Conditions
t_{PLH}	140	ns	I_I = 13mAdc, R_L = 510Ω, C_L = 50pF
t_{PHL}	120	ns	I_I = 13mAdc, R_L = 510Ω, C_L = 50pF

Subgroup 11
Switching tests at $T_A = -55°C$

Symbol	Max.	Units	Test Conditions
t_{PLH}	140	ns	I_I = 13mAdc, R_L = 510Ω, C_L = 50pF
t_{PHL}	120	ns	I_I = 13mAdc, R_L = 510Ω, C_L = 50pF

*Limits and conditions per Electrical Characteristics Table.

Application Circuits*

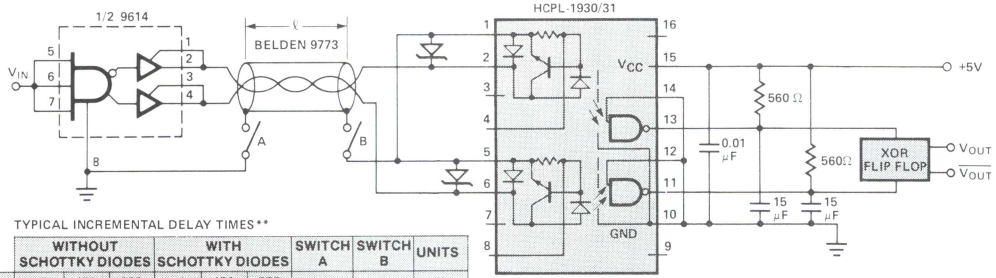


TYPICAL INCREMENTAL DELAY TIMES**

	R = 0, C = OPEN			R =33Ω, C = OPEN			R=33Ω, C = 390pF			UNITS
ℓ	<1	150	300	<1	150	300	<1	150	300	m
t_{PHL}	42	27	121	43	47	171	28	37	146	nsec
t_{PLH}	31	121	296	31	31	71	26	11	46	nsec

PROPAGATION DELAY TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS.

Figure A_1 Polarity Non-Reversing.

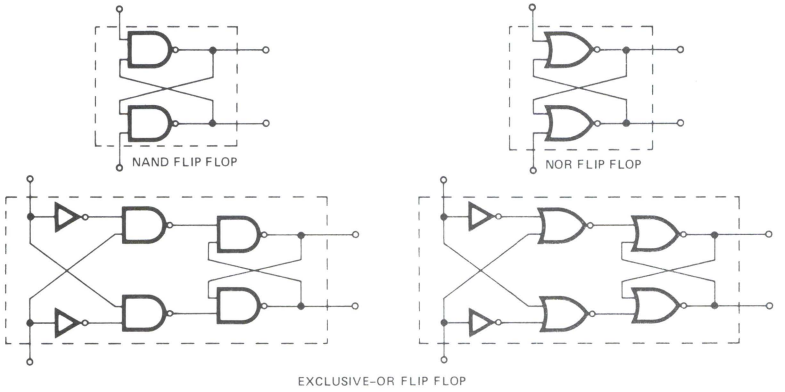


TYPICAL INCREMENTAL DELAY TIMES**

	WITHOUT SCHOTTKY DIODES			WITH SCHOTTKY DIODES			SWITCH A	SWITCH B	UNITS
ℓ	<1	150	300	<1	150	300	—	—	m
tp	112	455	820	78	365	700	OPEN	OPEN	nsec
	52	410	730	54	305	580	OPEN	CLOSED	nsec
	52	410	490	54	395	490	CLOSED	CLOSED	nsec

PROPAGATION DELAY TIMES SHOWN EXCLUDE DRIVER AND LINE DELAYS
USING 1/3 74LSO4 INVERTERS AND 74LS00 QUAD NAND

Figure A_2 Polarity Reversing, Split Phase.



NAND flip flop tolerates simultaneously HIGH inputs; NOR flip flop tolerates simultaneously LOW inputs; EXCLUSIVE-OR flip flop tolerates simultaneously HIGH OR LOW inputs without causing either of the outputs to change.

Figure A_3 Flip Flop Configurations.

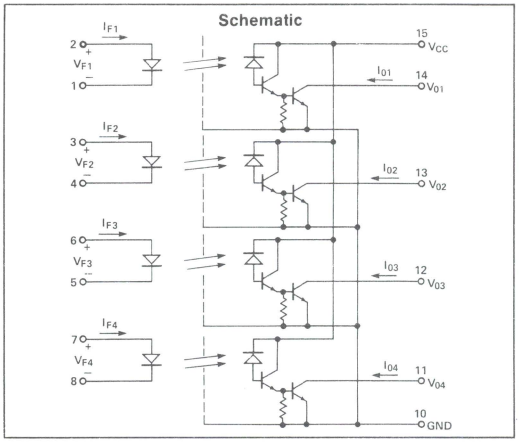
*FOR A DESCRIPTION OF THESE CIRCUITS SEE HCPL-2602 DATA SHEET.

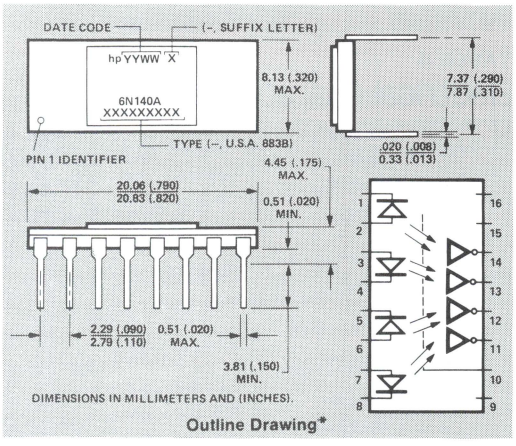
**THE INCREMENTAL DELAY TIMES ARE THE TIME DIFFERENCES BETWEEN THE TIME AT WHICH THE OUTPUT VOLTAGE CROSSES THE 1.5-V LEVEL AND THE TIME AT WHICH THE VOLTAGE WAVEFORM CROSSES 50% ON A RESISTIVE TERMINATION OF THE TRANSMISSION LINE.

HEWLETT PACKARD

HERMETICALLY SEALED FOUR CHANNEL LOW INPUT CURRENT OPTOCOUPLER

6N140A
6N140A/883B





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- PERFORMANCE GUARANTEED OVER –55° C TO +125° C AMBIENT TEMPERATURE RANGE
- MIL-STD-883 CLASS B TESTING
- HIGH DENSITY PACKAGING
- NEW—INTERNAL SHIELD FOR HIGHER CMR
- HERMETICALLY SEALED
- LOW INPUT CURRENT REQUIREMENT: 0.5 mA
- HIGH CURRENT TRANSFER RATIO: 1500% TYPICAL
- LOW OUTPUT SATURATION VOLTAGE: 0.1 V TYPICAL
- LOW POWER CONSUMPTION
- 1500 Vdc WITHSTAND TEST VOLTAGE
- HIGH RADIATION IMMUNITY
- HCPL-2730/2731 FUNCTION COMPATIBILITY

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- ISOLATED INPUT LINE RECEIVER
- SYSTEM TEST EQUIPMENT ISOLATION
- DIGITAL LOGIC GROUND ISOLATION
- EIA RS-232C LINE RECEIVER
- MICROPROCESSOR SYSTEM INTERFACE
- CURRENT LOOP RECEIVER
- LEVEL SHIFTING
- PROCESS CONTROL INPUT/OUTPUT ISOLATION

Description

The 6N140A is an EIA registered hybrid microcircuit which is capable of operation over the full military temperature range from –55° C to +125° C and is electrically and functionally identical to the 6N140 part. It is an advanced replacement unit for the 6N140. Performance of the 6N140A over the full military temperature range results from an improved integrated bypass resistor which shunts photodiode and first stage leakage currents.

The 6N140A contains four GaAsP light emitting diodes, each of which is optically coupled to a corresponding integrated high gain photon detector. The high gain output stage features an open collector output providing both lower output saturation voltage and higher speed operation than possible with conventional photo-darlington type optocouplers. Also, the separate V_{CC} pin can be strobed low as an output disable or operated with supply voltages as low as 2.0V without adversely affecting the parametric performance.

The high current transfer ratio at very low input currents permits circuit designs in which adequate margin can be allowed for the effects of CTR degradation over time.

The 6N140A has a 300% minimum CTR at an input current of only 0.5mA making it ideal for use in low input current applications such as MOS, CMOS and low power logic interfacing or RS-232C data transmission systems. Compatibility with high voltage CMOS logic systems is assured by the 18V V_{CC} and by the guaranteed maximum output leakage (I_{OH}) at 18V. The shallow depth of the IC photodiode provides better radiation immunity than conventional phototransistor couplers.

See the selection guide at the front of this section for other devices in this family.

*JEDEC Registered Data

TABLE I

Recommended Operating Conditions

	Symbol	Min.	Max.	Units
Input Current, Low Level (Each Channel)	I_{FL}		2	μA
Input Current, High Level (Each Channel)	I_{FH}	0.5	5	mA
Supply Voltage	V_{CC}	2.0	18	V

Absolute Maximum Ratings*

Storage Temperature ..... -65°C to +150°C
Operating Temperature ..... -55°C to +125°C
Lead Solder Temperature ..... 260°C for 10 s. (1.6mm below seating plane)
Output Current, I_O (each channel) ..... 40 mA
Output Voltage, V_O (each channel) ..... -0.5 to 20 V[1]
Supply Voltage, V_{CC} ..... -0.5 to 20 V[1]
Output Power Dissipation (each channel) ... 50 mW[2]
Peak Input Current (each channel, ≤1 ms duration, 500 pps) ..... 20 mA
Average Input Current, I_F (each channel) ..... 10 mA[3]
Reverse Input Voltage, V_R (each channel) 5V

TABLE II

Electrical Characteristics $T_A = -55°C$ to 125°C, Unless Otherwise Specified

Parameter	Symbol	Min.	Typ.**	Max.	Units	Test Conditions	Fig.	Note
Current Transfer Ratio	CTR*	300 300 200	1500 1000 500		% % %	I_F=0.5mA, V_O=0.4V, V_{CC}=4.5V I_F=1.6mA, V_O=0.4V, V_{CC}=4.5V I_F=5mA, V_O=0.4V, V_{CC}=4.5V	3	4,5
Logic Low Output Voltage	V_{OL}		.1 .2	.4 .4	V V	I_F=0.5mA, I_{OL}=1.5mA, V_{CC}=4.5V I_F=5mA, I_{OL}=10mA, V_{CC}=4.5V	2	4
Logic High Output Current	$\frac{I_{OHX}}{I_{OH}}$*		.001	250	μA	I_F=2μA (channel under test) V_O=V_{CC}=18V		4,6 4
Logic Low Supply Current	I_{CCL}*		1.7	4	mA	I_{F1}=I_{F2}=I_{F3}=I_{F4}=1.6mA V_{CC}=18V		
Logic High Supply Current	I_{CCH}*		.001	40	μA	I_{F1}=I_{F2}=I_{F3}=I_{F4}=0 V_{CC}=18V		
Input Forward Voltage	V_F*		1.44	1.7	V	I_F=1.6mA, T_A=25°C	1	4
Input Reverse Breakdown Voltage	BV_R*	5			V	I_R=10μA, T_A=25°C		4
Input-Output Insulation Leakage Current	I_{I-O}*			1.0	μA	45% Relative Humidity, T_A=25°C, t=5s., V_{I-O}=1500 Vdc		7,13
Propagation Delay Time To Logic High At Output	t_{PLH}*		6	60	μs	I_F=0.5mA, R_L=4.7kΩ, V_{CC}=5.0V, T_A=25°C	8	4
			4	20	μs	I_F=5mA, R_L=680Ω, V_{CC}=5.0V, T_A=25°C	8	4
Propagation Delay Time To Logic Low At Output	t_{PHL}*		30	100	μs	I_F=0.5mA, R_L=4.7kΩ, V_{CC}=5.0V, T_A=25°C	8	4
			2	5	μs	I_F=5mA, R_L=680Ω, V_{CC}=5.0V, T_A=25°C	8	4
Common Mode Transient Immunity At Logic High Level Output	$\|CM_H\|$	500	1000		V/μs	I_F=0, R_L=1.5kΩ $\|V_{CM}\|$=50V_{p-p}, V_{CC}=5.0V, T_A=25°C	9	4 10,12
Common Mode Transient Immunity At Logic Low Level Output	$\|CM_L\|$	500	1000		V/μs	I_F=1.6mA, R_L=1.5kΩ $\|V_{CM}\|$=50V_{p-p}, V_{CC}=5.0V, T_A=25°C	9	4 11,12

*JEDEC Registered Data
**All typical values are at V_{CC} = 5V, T_A = 25°C.

TABLE III

Typical Characteristics T_A = 25°C, V_{CC} = 5V Each Channel

Parameter	Symbol	Min.	Typ.	Max.	Units	Test Conditions	Fig.	Note
Resistance (Input-Output)	R_{I-O}		10^{12}		Ω	V_{I-O}=500 Vdc, T_A=25°C		4,8
Capacitance (Input-Output)	C_{I-O}		1.5		pF	f=1MHz, T_A=25°C		4,8
Input-Input Insulation Leakage Current	I_{I-I}		0.5		nA	45% Relative Humidity, V_{I-I}=500 Vdc, T_A=25°C, t=5s.		9
Resistance (Input-Input)	R_{I-I}		10^{12}		Ω	V_{I-I}=500Vdc, T_A=25°C		9
Capacitance (Input-Input)	C_{I-I}		1		pF	f=1MHz, T_A=25°C		9
Temperature Coefficient of Forward Voltage	$\frac{\Delta V_F}{\Delta T_A}$		-1.8		mV/°C	I_F=1.6mA		4
Input Capacitance	C_{IN}		60		pF	f=1MHz, V_F=0, T_A=25°C		4

NOTES:
1. Pin 10 should be the most negative voltage at the detector side. Keeping V_{CC} as low as possible, but greater than 2.0 volts, will provide lowest total I_{OH} over temperature.
2. Output power is collector output power plus one fourth of total supply power. Derate at 1.66mW/°C above 110°C.
3. Derate I_F at 0.33mA/°C above 110°C.
4. Each channel.
5. CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
6. I_{OHX} is the leakage current resulting from channel to channel optical crosstalk. I_F = 2μA for channel under test. For all other channels, I_F = 10mA.
7. Device considered a two-terminal device: Pins 1 through 8 are shorted together and pins 9 through 16 are shorted together.
8. Measured between the LED anode and cathode shorted together and pins 10 through 15 shorted together.
9. Measured between adjacent input pairs shorted together, i.e. between pins 1 and 2 shorted together and pins 3 and 4 shorted together, etc.
10. CM_H is the maximum tolerable common mode transient to assure that the output will remain in a high logic state (i.e. V_O > 2.0V).
11. CM_L is the maximum tolerable common mode transient to assure that the output will remain in a low logic state (i.e. V_O < 0.8V).
12. In applications where dV/dt may exceed 50,000 V/μs (such as a static discharge) a series resistor, R_{CC}, should be included to protect the detector IC's from destructively high surge currents. The recommended value is $R_{CC} = \frac{1V}{0.6\ I_F\ (mA)}$ kΩ.
13. This is a momentary withstand test, not an operating condition.

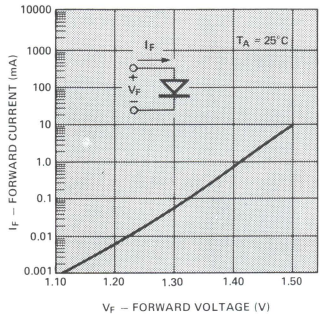


Figure 1. Input Diode Forward Current vs. Forward Voltage.

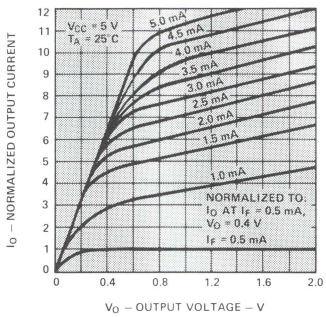


Figure 2. Normalized DC Transfer Characteristics

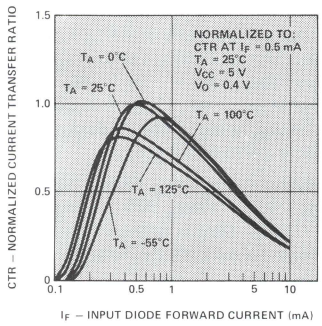


Figure 3. Normalized Current Transfer Ratio vs. Input Diode Forward Current.

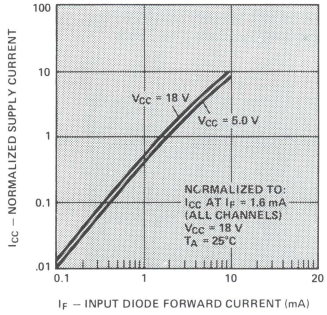


Figure 4. Normalized Supply Current vs. Input Diode Forward Current.

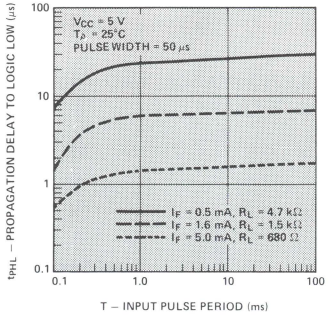


Figure 5. Propagation Delay to Logic Low vs. Input Pulse Period.

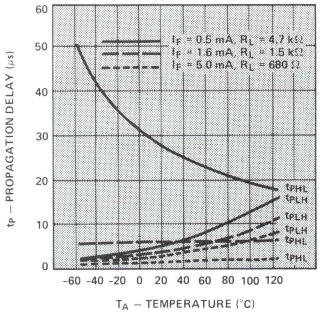


Figure 6. Propagation Delay vs. Temperature

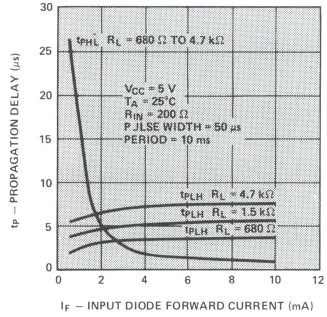
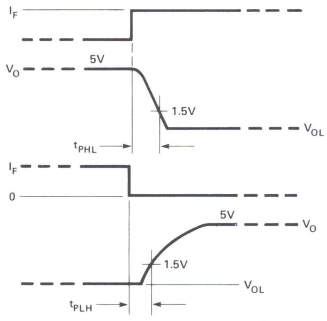


Figure 7. Propagation Delay vs. Input Diode Forward Current.



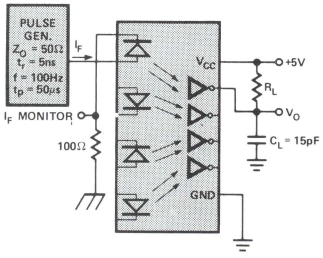
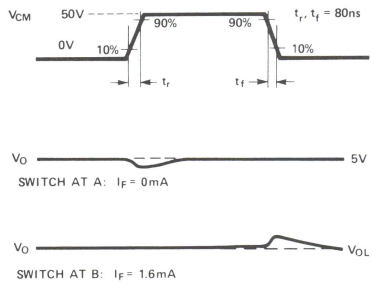


Figure 8. Switching Test Circuit.* (t_f, t_p not JEDEC registered)



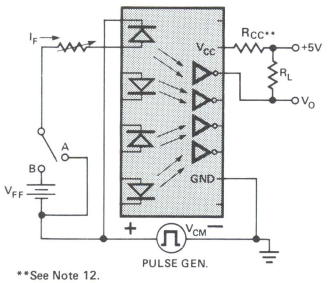


Figure 9. Test Circuit for Transient Immunity and Typical Waveforms.

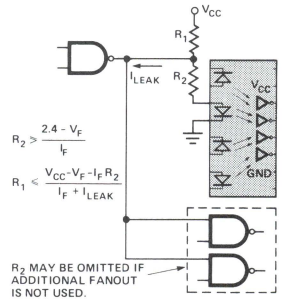


Figure 10. Recommended Drive Circuitry Using TTL Logic.

*JEDEC Registered Data

MIL-STD-883 CLASS B TEST PROGRAM

Hewlett Packard's 883B Optocouplers are in compliance with MIL-STD-883, Revision C. Deviations listed below are specifically allowed in DESC drawing 83024 for an H.P. Optocoupler from the same generic family using the same manufacturing process, design rules and elements of the same microcircuit group.

Testing consists of 100% screening to Method 5004 and quality conformance inspection to Method 5005 of MIL-STD-883. Details of these test programs may be found in Hewlett-Packard's Optoelectronics Designer's Catalog.

6N140A/883B Clarifications:

I. 100% screening per MIL-STD-883, Method 5004 constant acceleration — condition A not E.

II. Quality Conformance Inspection per MIL-STD-883, Method 5005, Group A,B,C and D.
Group A — See table below for specific electrical tests.
Group B — No change
Group C — Constant Acceleration — Condition A not E.
Group D — Constant Acceleration — Condition A not E.

PART NUMBERING SYSTEM

Commercial Product	Class B Product
6N140A	6N140A/883B

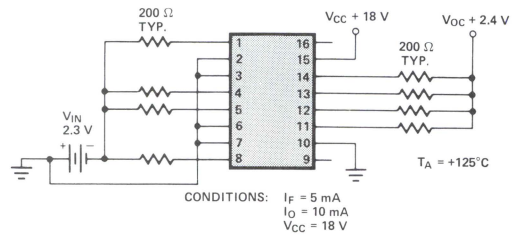


Figure 11. Operating Circuit for Burn-In and Steady State Life Tests.

GROUP A — ELECTRICAL TESTS QUANTITY/ACCEPT NO. = 116/0

Subgroup 1
*Static tests at $T_A = 25°C$ – I_{OH}, I_{OHX}, I_{CCL}, I_{CCH}, CTR, V_F, BV_R and I_{I-O}

Subgroup 2
*Static tests at $T_A = +125°C$ – I_{OH}, I_{OHX}, I_{CCL}, I_{CCH}, CTR

Symbol	Min.	Max.	Units	Test Conditions
V_F		1.7	V	$I_F = 1.6$ mA
BV_R	5		V	$I_R = 10\ \mu A$

Subgroup 3
*Static tests at $T_A = -55°C$ – I_{OH}, I_{OHX}, I_{CCL}, I_{CCH}, CTR

Symbol	Min.	Max.	Units	Test Conditions
V_F		1.8	V	$I_F = 1.6$ mA
BV_R	5		V	$I_R = 10\ \mu A$

Subgroup 4, 5, 6, 7, 8A and 8B
These subgroups are not applicable to this device type.

Subgroup 9
*Switching tests at $T_A = 25°C$ – t_{PLH1}, t_{PHL1}, t_{PLH2}, t_{PHL2}, CM_H and CM_L

Subgroup 10
Switching tests at $T_A = +125°C$

Symbol	Max.	Units	Test Conditions	
t_{PLH1}	60	μs	$I_F = 0.5$ mA, $R_L = 4.7$ kΩ	$V_{CC} = 5.0$ V
t_{PLH2}	30	μs	$I_F = 5$ mA, $R_L = 680\ \Omega$	$V_{CC} = 5.0$ V
t_{PHL1}	100	μs	$I_F = 0.5$ mA, $R_L = 4.7$ kΩ	$V_{CC} = 5.0$ V
t_{PHL2}	10	μs	$I_F = 5$ mA, $R_L = 680\ \Omega$	$V_{CC} = 5.0$ V

Subgroup 11
Switching tests at $T_A = -55°C$

Symbol	Max.	Units	Test Conditions	
t_{PLH1}	60	μs	$I_F = 0.5$ mA, $R_L = 4.7$ kΩ	$V_{CC} = 5.0$ V
t_{PLH2}	30	μs	$I_F = 5$ mA, $R_L = 680\ \Omega$	$V_{CC} = 5.0$ V
t_{PHL1}	100	μs	$I_F = 0.5$ mA, $R_L = 4.7$ kΩ	$V_{CC} = 5.0$ V
t_{PHL2}	10	μs	$I_F = 5$ mA, $R_L = 680\ \Omega$	$V_{CC} = 5.0$ V

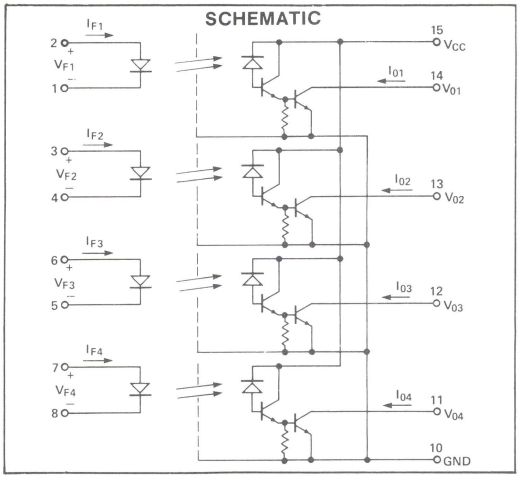
*Limits and conditions per Table II.

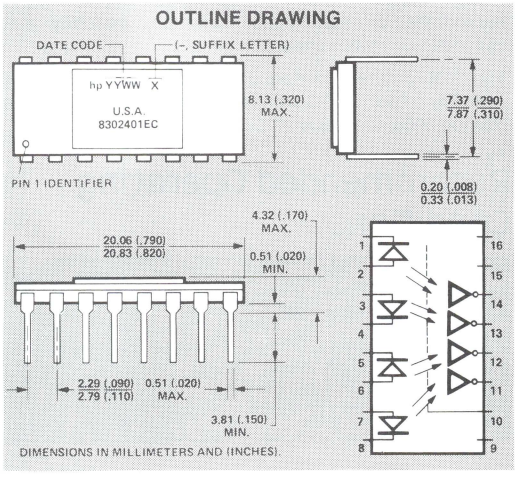
HEWLETT PACKARD

FOUR CHANNEL HERMETICALLY SEALED OPTOCOUPLER

DESC APPROVED

8302401EC





Features

- NEW—MANUFACTURED AND TESTED ON A MIL-STD-1772 CERTIFIED LINE
- RECOGNIZED BY DESC*
- HERMETICALLY SEALED
- MIL-STD-883 CLASS B TESTING
- HIGH DENSITY PACKAGING
- NEW—INTERNAL SHIELD FOR HIGHER CMR
- PERFORMANCE GUARANTEED OVER −55° C TO +125° C AMBIENT TEMPERATURE RANGE
- 1500 V dc WITHSTAND TEST VOLTAGE
- LOW INPUT CURRENT REQUIREMENT: 0.5 mA
- HIGH CURRENT TRANSFER RATIO: 1500% TYPICAL
- LOW OUTPUT SATURATION VOLTAGE: 0.1 V TYPICAL
- LOW POWER CONSUMPTION
- HIGH RADIATION IMMUNITY

Applications

- MILITARY/HIGH RELIABILITY SYSTEMS
- ISOLATED INPUT LINE RECEIVER
- SYSTEM TEST EQUIPMENT ISOLATION
- DIGITAL LOGIC GROUND ISOLATION
- EIA RS-232C LINE RECEIVER
- MICROPROCESSOR SYSTEM INTERFACE
- CURRENT LOOP RECEIVER
- LEVEL SHIFTING
- PROCESS CONTROL INPUT/OUTPUT ISOLATION

Description

The 8302401EC is the DESC selected item drawing assigned by DOD for the 6N140A optocoupler which is in accordance with MIL-STD-883 class B testing. Operating characteristic curves for this part can be seen in the 6N140A data sheet. This hybrid microcircuit is capable of operation over the full military temperature range from −55° C to +125° C.

The 8302401EC contains four GaAsP light emitting diodes, each of which is optically coupled to a corresponding integrated high gain photon detector. The high gain output stage features an open collector output providing both lower output saturation voltage and higher speed operation than possible with conventional photo-darlington type opto-couplers. Also, the separate V_{CC} pin can be strobed low as an output disable or operated with supply voltages as low as 2.0V without adversely affecting the parametric performance.

(Continued on next page)

*Defense Electronic Supply Center (DESC) is an agency of the Department of Defense (DOD).

The high current transfer ratio at very low input currents permits circuit designs in which adequate margin can be allowed for the effects of CTR degradation over time.

The 8302401EC has a 300% minimum CTR at an input current of only 0.5mA making it ideal for use in low input current applications such as MOS, CMOS and low power logic interfacing or RS-232C data transmission systems. Compatibility with high voltage CMOS logic systems is assured by the 18V V_{CC} and by the guaranteed maximum output leakage (I_{OH}) at 18V. The shallow depth of the IC photodiode provides better radiation immunity than conventional phototransistor couplers.

The test program performed on the 8302401EC is in compliance with DESC drawing 83024 and the provisions of method 5008, Class B of MIL-STD-883.

Absolute Maximum Ratings

Storage Temperature Range ..... −65° C to +150° C
Operating Temperature ..... −55° C to +125° C
Lead Solder Temperature ..... 260° C for 10 s. (1.6mm below seating plane)
Output Current, I_O (each channel) ..... 40 mA
Output Voltage, V_O (each channel) ..... −0.5 to 20 V [1]
Supply Voltage, V_{CC} ..... −0.5 to 20 V [1]
Output Power Dissipation (each channel) ..... 50 mW [2]
Peak Input Current (each channel, ≤ 1 ms duration) ..... 20 mA
Average Input Current, I_F (each channel) ..... 10 mA [3]
Reverse Input Voltage, V_R (each channel) 5V

Recommended Operating Conditions

	Symbol	Min.	Max.	Units
Input Current, Low Level (Each Channel)	I_{FL}		2	μA
Input Current, High Level (Each Channel)	I_{FH}	0.5	5	mA
Supply Voltage	V_{CC}	2.0	18	V

100% Screening

MIL-STD-883, METHOD 5004 (CLASS B DEVICES)

Test Screen	Method	Conditions
1. Precap Internal Visual	2017	
2. High Temperature Storage	1008	Condition C, T_A = 150° C, Time = 24 hours minimum
3. Temperature Cycling	1010	Condition C, −65° C to +150° C, 10 cycles
4. Constant Acceleration	2001	Condition A, 5KG's, Y_1 and Y_2 axis only
5. Fine Leak	1014	Condition A
6. Gross Leak	1014	Condition C
7. Interim Electrical Test	—	Optional
8. Burn-In	1015	Condition B, Time = 160 hours minimum T_A = +125° C, V_{CC} = 18V, I_F = 5 mA, I_O = 10 mA (Figure 1)
9. Final Electrical Test Electrical Test	—	Group A, Subgroup 1, 5% PDA applies Group A, Subgroup 2, 3, 9
10. External Visual	2009	

Quality Conformance Inspection

GROUP A ELECTRICAL PERFORMANCE CHARACTERISTICS

QUANTITY/ACCEPT NO. = 116/0

Parameter	Symbol	Test Conditions	Group A Subgroups	Limits Min.	Limits Max.	Unit	Note
Current Transfer Ratio	$h_{F(CTR)}$	I_F=0.5mA, V_O=0.4V, V_{CC}=4.5V	1, 2, 3	300		%	4, 5
		I_F=1.6mA, V_O=0.4V, V_{CC}=4.5V	1, 2, 3	300		%	4, 5
		I_F=5mA, V_O=0.4V, V_{CC}=4.5V	1, 2, 3	200		%	4, 5
Logic Low Output Voltage	V_{OL}	I_F=0.5mA, I_{OL}=1.5mA, V_{CC}=4.5V	1, 2, 3		0.4	V	4
		I_F=5mA, I_{OL}=10mA, V_{CC}=4.5V	1, 2, 3		0.4	V	4
Logic High Output Current	I_{OH}	I_F=2μA	1, 2, 3		250	μA	4
	I_{OHX}	V_O=V_{CC}=18V	1, 2, 3		250	μA	4, 6
Logic Low Supply Current	I_{CCL}	I_{F1}=I_{F2}=I_{F3}=I_{F4}=1.6mA, V_{CC}=18V	1, 2, 3		4	mA	
Logic High Supply Current	I_{CCH}	I_{F1}=I_{F2}=I_{F3}=I_{F4}=0mA, V_{CC}=18V	1, 2, 3		40	μA	
Input Forward Voltage	V_F	I_F=1.6mA	1, 2		1.7	V	4
			3		1.8	V	4
Input Reverse Breakdown Voltage	BV_R	I_R=10μA	1, 2, 3	5		V	4
Input-Output Insulation Leakage Current	I_{I-O}	45% Relative Humidity, T=25°C, t=5s., V_{I-O}=1500 Vdc	1		1.0	μA	7, 12
Capacitance Between Input-Output	C_{I-O}	f=1MHz, T_C=25°C	4		4	pF	4, 8
Propagation Delay Time To Logic High At Output	t_{PLH}	I_F=0.5mA, R_L=4.7kΩ, V_{CC}=5.0V	9, 10, 11		60	μs	
		I_F=5mA, R_L=680Ω, V_{CC}=5.0V	9		20	μs	
			10, 11		30	μs	
Propagation Delay Time To Logic Low At Output	t_{PHL}	I_F=0.5mA, R_L=4.7kΩ, V_{CC}=5.0V	9, 10, 11		100	μs	
		I_F=5mA, R_L=680Ω, V_{CC}=5.0V	9		5	μs	
			10, 11		10	μs	
Common Mode Transient Immunity At Logic High Level Output	$\|CM_H\|$	I_F=0, R_L=1.5kΩ, $\|V_{CM}\|$=25V_{p-p}, V_{CC}=5.0V	9, 10, 11	500		V/μs	9, 11
Common Mode Transient Immunity At Logic Low Level Output	$\|CM_L\|$	I_F=1.6mA, R_L=1.5kΩ, $\|V_{CM}\|$=25V_{p-p}, V_{CC}=5.0V	9, 10, 11	500		V/μs	10, 11

NOTES:
1. Pin 10 should be the most negative voltage at the detector side. Keeping V_{CC} as low as possible, but greater than 2.0 volts, will provide lowest total I_{OH} over temperature.
2. Output power is collector output power plus one fourth of total supply power. Derate at 1.66mW/°C above 110°C.
3. Derate I_F at 0.33mA/°C above 110°C.
4. Each channel
5. CURRENT TRANSFER RATIO is defined as the ratio of output collector current, I_O, to the forward LED input current, I_F, times 100%.
6. I_{OHX} is the leakage current resulting from channel to channel optical crosstalk. I_F = 2μA for channel under test. For all other channels, I_F = 10mA.
7. Device considered a two-terminal device: Pins 1 through 8 are shorted together and pins 9 through 16 are shorted together.
8. Measured between the LED anode and cathode shorted together and pins 10 through 15 shorted together.
9. CM_H is the maximum tolerable common mode transient to assure that the output will remain in a high logic state (i.e. V_O > 2.0V).
10. CM_L is the maximum tolerable common mode transient to assure that the output will remain in a low logic state (i.e. V_O < 0.8V).
11. In applications where dV/dt may exceed 50,000 V/μs (such as a static discharge) a series resistor, R_{CC}, should be included to protect the detector IC's from destructively high surge currents. The recommended value is

$$R_{CC} \approx \frac{1V}{0.6\ I_F\ (mA)}\ k\Omega.$$

12. This is a momentary withstand test, not an operating condition.

GROUP B TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)

Test	Method	Conditions	LTPD
Subgroup 1 Physical Dimensions (Not required if Group D is to be performed)	2016		2 Devices (no failures)
Subgroup 2 Resistance to Solvents	2015		4 Devices (no failures)
Subgroup 3 Solderability (LTPD applies to number of leads inspected — no fewer than 3 devices shall be used).	2003	Soldering Temperature of 245 ± 5° C for 10 seconds	10 (3 Devices)
Subgroup 4 Internal Visual and Mechanical	2014		1 Device (no failures)
Subgroup 5 Bond Strength Thermocompression: (Performed at precap, prior to seal LTPD applies to number of bond).	2011	Test Condition D	15
Subgroup 6 Internal Water Vapor Content (Not applicable — does not contain desiccant)	—		—
Subgroup 7* Electrical Test Electrostatic Discharge Sensitivity Electrical Test *(To be performed at initial qualification only)	3015	Group A, and Delta Limits in Accordance with Method 3015 Group A, and Delta Limits in Accordance with Method 3015	3(0) with repeat for cumulative effects 15(0)

GROUP C TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)

Test	Method	Conditions	LTPD
Subgroup 1 Steady State Life Test	1005	Condition B, Time = 1000 hours total T_A = +125° C, V_{CC} = 18 V, I_F = 5 mA, I_O = 10 mA (Figure 1)	5
Endpoint Electricals at 1000 hours		Group A, Subgroup 1, 2, 3	
Subgroup 2 Temperature Cycling	1010	Condition C, −65° C to +150° C, 10 cycles	15
Constant Acceleration	2001	Condition A, 5KG's, Y_1 and Y_2 axis only	
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1010	Per Visual Criteria of Method 1010	
Endpoint Electricals		Group A, Subgroup 1, 2, 3	

GROUP D TESTING MIL-STD-883, METHOD 5005 (CLASS B DEVICES)

Test	Method	Conditions	LTPD
Subgroup 1			
Physical Dimensions	2016		15
Subgroup 2			
Lead Integrity	2004	Test Condition B2 (lead fatigue)	15
Subgroup 3			
Thermal Shock	1011	Condition B, (−55° C to +125° C) 15 cycles min.	15
Temperature Cycling	1010	Condition C, (−65° C to +150° C) 100 cycles min.	
Moisture Resistance	1004		
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination		Per Visual Criteria of Method 1004,1010	
Endpoint Electricals		Group A, Subgroup 1, 2, 3	
Subgroup 4			
Mechanical Shock	2002	Condition B, 1500G, t = 0.5 ms, 5 blows in each orientation	15
Vibration Variable Frequency	2007	Condition A	
Constant Acceleration	2001	Condition A,5KG's,Y_1 and Y_2 axis only	
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1010	Per Visual Criteria of Method 1010	
Endpoint Electricals		Group A, Subgroup 1, 2, 3	
Subgroup 5			
Salt Atmosphere	1009	Condition A min.	15
Fine Leak	1014	Condition A	
Gross Leak	1014	Condition C	
Visual Examination	1009	Per Visual Criteria of Method 1009	
Subgroup 6			
Internal Water Vapor Content	1018	5,000 ppm Maximum Water content at 100° C	3 Devices (0 failures) 5 Devices (1 failure)
Subgroup 7			
Adhesion of Lead Finish	2025		15
Subgroup 8			
Lid Torque (not applicable—solder seal)	2024		5 Devices (0 failures)

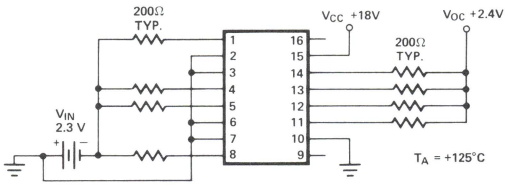


Figure 1. Operating Circuit for Burn-In and Steady State Life Tests.

Applications

- **Application Bulletins, Notes, Handbooks, and Manual Listing**
- **Abstracts**

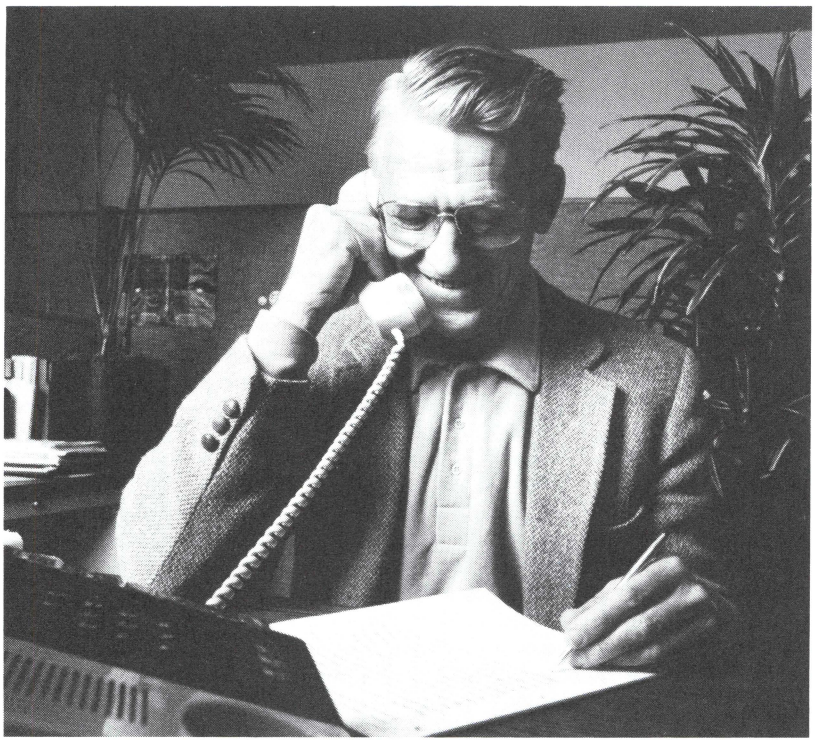
Applications

Because technology is growing and changing so rapidly, HP's commitment to customers includes an extensive applications department. In an effort to anticipate design needs and answer design questions, this team of engineers has published a complete library of applications literature. This literature is available, free of charge, through HP sales and service offices, authorized distributors, and direct from the factory.

This section contains a listing of all available application bulletins, application notes, technical briefs, and designer guides.

Also available for $12 each are application handbooks which contain complete application notes bound together with additional product information, allowing you to keep the design information you need from year-to-year.

These handbooks are available through your local authorized distributor. A listing of these distributors can be found in the appendix.



Applications Listing

MOTION SENSING AND CONTROL

Model Pub. No. (Date)	Description
AN-1011 5953-9393 (12/83)	Design and Operational Considerations for the HEDS-5000 Incremental Shaft Encoder
AN-1025 5954-0920 (9/85)	Applications and Circuit Design for the HEDS-7500 series Digital Potentiometer
AN-1032 5954-0932 (4/86)	Design of the HCTL-1000's Digital Filter Parameters by the Combination Method

BAR CODE COMPONENTS

Model Pub. No. (Date)	Description
AB-59 5953-9365 (7/83)	HP 16800A/16801A Bar Code Reader Configuration Guide for a DEC VT-100 or Lear Siegler ADM-31 to a DEC PDP-11 Computer
AB-61 5953-9361 (8/83)	HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 3276/3278 Terminal
AB-62 5953-9362 (8/83)	HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 4955F Series 1 Process Control CPU/Protocol Converter and an IBM 3101 Terminal
AB-63 5953-9363 (8/83)	HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 5101 Personal Computer
AB-68 5953-9382 (11/83)	HP 16800A/16801A Bar Code Reader Configuration Guide for a MICOM Micro280 Message Concentrator
AB-75 5954-2170 (12/86)	ESD Control in Portable Bar Code Readers
AB-77 5954-2176 (9/87)	Interfacing the HP SmartWand
AB-1008 5953-0460 (1/81)	Optical Sensing with the HEDS-1000
AN-1013 5953-9387 (11/83)	Elements of a Bar Code System

OPTOCOUPLERS

Model Pub. No. (Date)	Description
TB-103 5954-1017 (7/85)	High Speed Optocouplers vs. Pulse Transformer
AB-60 5953-9347(4/83)	Applications Circuits for HCPL-3700 and HCPL-2601
AB-69 5953-9384 (10/83)	CMOS Circuit Design using Hewlett-Packard Optocouplers
AN-939 5953-9368 (10/73)	High Speed Optocouplers
AN-947 5953-7759 (6/82)	Digital Data Transmission Using Optically Coupled Isolators
AN-948 5953-7716 (12/81)	Performance of the 6N135, 6N136 and 6N137 Optocouplers in Short to Moderate Length Digital Data Transmission Systems
AN-951-1 5953-7794 (10/82)	Applications for Low Input Current, High Gain Optocouplers
AN-951-2 5963-7730 (4/82)	Linear Applications of Optocouplers
AN-1002 5953-7799 (10/82)	Consideration of CTR Variations in Optically Coupled Isolator Circuit Designs
AN-1004 5953-0406 (11/79)	Threshold Sensing for Industrial Control Systems with the HCPL-3700 Interface Optocoupler
AN-1018 5953-9359 (8/83)	Designing with HCPL-4100 and HCPL-4200 20 mA Optocouplers
AN-1023 5954-1003 (3/85)	Radiation Immunity of HP Optocouplers
AN-1024 5954-1006 (3/85)	Ring Detection with the HCPL-3700 Optocoupler

FIBER OPTICS

Model Pub. No. (Date)	Description
AB-65 5953-9370 (9/83)	Using 50/125 μm Optical Fiber with Hewlett-Packard Components
AB-71 5954-1021 (12/85)	Using 200 μm PCS Optical Fiber with HP Components
AB-73 5954-8415 (6/87)	Low-Cost Fiber Optic Transmitter and Receiver Interface Circuits
AN-915 5953-0431 (4/80)	Threshold Detection of Visible and Infrared Radiation with PIN Photodiodes
AN-1022 5954-0979 (1/85)	High Speed Fiber Optic Link Design with Discrete Components
TB-101 5954-1004 (4/85)	Fiber Optic SMA Connector Technology
TB-102 5954-1011 (5/85)	Fiber/Cable Selection for LED Based Local Communications Systems
TB-104 5954-1025 (12/85)	Baseband Video Transmission with Low Cost Fiber Optic Components
TB-105 5954-8436 (6/87)	ST Connector/Cable Guide

LIGHT BARS AND BAR GRAPH ARRAYS

Model Pub. No. (Date)	Description
AN-1007 5953-0452 (1/81)	Bar Graph Array Applications
AN-1012 5953-0478 (2/81)	Methods of Legend Fabrication

SOLID STATE LAMPS

Model Pub. No. (Date)	Description
AB-1 5952-8378 (1/75)	Construction and Performance of High Efficiency Red, Yellow and Green LED Materials
AB-74 5954-8402 (11/86)	Auto-Insertion of Option 002 Tape and Reel LED Lamps

SOLID STATE LAMPS (Cont.)

Model Pub. No. (Date)	Description
AN-945 5952-0420 (10/73)	Photometry of Red LEDs
AN-1005 5953-0419 (3/80)	Operational Considerations for LED Lamps and Display Devices
AN-1017 5953-7784 (10/82)	LED Solid State Reliability
AN-1019 5954-0921 (1/86)	Using the HLMP-4700/-1700/-7000 Series Low Current Lamp
AN-1021 5953-0861 (5/84)	Utilizing LED Lamps Packaged on Tape and Reel
AN-1027 5954-0893 (7/85)	Soldering LED Components
AN-1028 5954-0902 (9/85)	Surface Mount Subminiature LED Lamps

SOLID STATE DISPLAYS

Model Pub. No. (Date)	Description
AB-4 5952-8381 (4/75)	Detection and Indication of Segment Failures in 7-Segment LED Displays
AB-64 5953-9366 (9/83)	Mechanical and Optical Considerations for the 0.3" Microbright Seven-Segment Display
AB-76 5954-8427 (5/87)	Use of LED Lamps and Displays in Night Vision Goggle Secure Lighting Applications
AN-934 5952-0337 (11/72)	5082-7300 Series Solid State Display Installation Techniques
AN-1006 5953-0439 (7/80)	Seven Segment LED Display Applications
AN-1015 5953-7788 (11/82)	Contrast Enhancement Techniques for LED Displays
AN-1016 5953-7787 (3/84)	Using the HDSP-2000 Alphanumeric Display Family
AN-1026 5954-0886 (6/85)	Designing with HP's Smart Display — the HPDL-2416
AN-1029 5954-0923 (2/86)	Luminous Contrast and Sunlight Readability of the HDSP-238X Series LED Alphanumeric Displays for Military Applications
AN-1031 5954-0933 (3/86)	Achieving Uniform Front Panel Appearance using Hewlett-Packard's S02 Option LED Devices
AN-1033 5954-8424 (3/87)	Designing with the HDSP-211X Smart Display Family

INK-JET COMPONENTS

Model Pub. No. (Date)	Description
Designer's Guide 5954-8535 (11/86)	Thermal Ink-Jet Print Cartridge Designer's Guide

APPLICATIONS HANDBOOKS

Model Pub. No. (Date)	Description
HPBK-4000 (1986) 5954-8416	LED Indicators and Displays Application Handbook $12
HPBK-5000 (1986) 5954-8417	Optocouplers and Fiber Optics Applications Handbook $12

Abstracts

APPLICATION BULLETIN 1
Construction and Performance of High Efficiency Red, Yellow and Green LED Materials

The high luminous efficiency of Hewlett-Packard's High Efficiency Red, Yellow and Green lamps and displays is made possible by a new kind of light emitting material utilizing a GaP transparent substrate. This application bulletin discusses the construction and performance of this material as compared to standard red GaAsP and red GaP materials.

APPLICATION BULLETIN 4
Detection and Indication of Segment Failures in Seven Segment LED Displays

The occurrence of a segment failure in certain applications of seven segment displays can have serious consequences if a resultant erroneous message is read by the viewer. This application bulletin discusses three techniques for detecting open segment lines and presenting this information to the viewer.

APPLICATION BULLETIN 59
HP16800A/16801A Bar Code Reader Configuration Guide for a DEC VT-100 or Lear Siegler ADM-31 to a DEC PDP-11 Computer

This application bulletin provides information to aid in configuring the HP 16800A/16801A bar code reader with a DEC-PDP-11 computer, and either a DEC-VT-100 terminal or a LEAR SIEGLER ADM-31 terminal.

APPLICATION BULLETIN 60
Applications Circuits for HCPL-3700 and HCPL-2601

Simple circuit illustrations are given for use of the HCPL-3700 threshold detection optocoupler for ac or dc sensing requirements. Programmable threshold levels are given for the HCPL-3700.

Also, a basic LSTTL to LSTTL isolation interface circuit for 10 MBd operation is given which uses the high common mode transient immunity HCPL-2601 optocoupler.

APPLICATION BULLETIN 61
HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 3276/3278 Terminal

This application bulletin provides information to aid in configuring the HP 16800A/16801A bar code reader with an IBM 3276/3278 terminal to an IBM 3272/3274 Remote Communications Controller. In this configuration the IBM 3272/3274 is connected to an IBM mainframe computer.

APPLICATION BULLETIN 62
HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 4955F Series 1 Process Control CPU/ Protocol Converter and an IBM 3101 Terminal

This application bulletin provides information to aid in configuring the HP 16800A/16801A bar code reader in an eavesdrop configuration with an IBM 3101 terminal and an IBM Series 1 Process Control CPU/Protocol Converter. In this configuration the IBM Series 1 is connected to an IBM mainframe computer.

APPLICATION BULLETIN 63
HP 16800A/16801A Bar Code Reader Configuration Guide for an IBM 5101 Personal Computer

This application bulletin provides information to aid in configuring the HP 16800A/16801A bar code reader with an IBM 5101 Personal Computer.

APPLICATION BULLETIN 64
Mechanical and Optical Considerations for the 0.3" Microbright Seven-Segment Display

The need to conserve space in electronic instruments has increased drastically in the drive to design more compact, more portable equipment. Hewlett-Packard has facilitated the saving of space in the design of front panels with the introduction of the Microbright, Hewlett-Packard's new HDSP-7300/-7400/-7500/-7800 series compact 0.3" seven segment displays. Smaller than the conventional 0.3" device, the Microbright requires less space without sacrificing display height and is also Hewlett-Packard's most sunlight viewable seven segment display.

This application bulletin deals with several issues in the use of the Microbright. Optical filtering is covered, with recommendations on filters to use over the devices. Adjusting the package height and recommended sockets are also presented, followed by a discussion on the brightness of the display.

APPLICATION BULLETIN 65
Using 50/125 μm Optical Fiber with Hewlett-Packard Components

Applications Bulletin 65 explains factors that influence the power coupled into various fiber diameters and numerical apertures. Test results showing coupled power from HP LED sources into 100/140 μ metre and 50/125 μ metre fiber are included.

APPLICATION BULLETIN 68
HP 16800A/16801A Bar Code Reader Configuration Guide for a MICOM Micro280 message concentrator

In some applications, multiple bar code readers may be required to input data to a logging terminal or a central processing unit. However, connecting each unit to a CPU may utilize more input/output ports than desired. A port concentrator will allow several devices to be connected using only one port to the CPU. This application bulletin provides information to aid in configuring the HP 16800A/16801A bar code reader with a MICOM Micro280 Message Concentrator.

Abstracts (cont.)

APPLICATION BULLETIN 69
CMOS Circuit Design Using Hewlett-Packard Optocouplers

Within this application bulletin are CMOS isolation interface circuits for use with the various, low input current, Hewlett-Packard optocouplers, specifically, the HCPL-2200/2300/2731 and 6N139 devices. Advantages of and recommendations for different input and output circuit configurations are given in tabular form for low power operation at various signalling rates.

APPLICATION BULLETIN 71
200-μm PCS Fiber with Hewlett-Packard Fiber Optic Transmitters and Receivers

A description of the properties of 200-μm PCS fiber is given and the performance when used with Hewlett-Packard fiber optic components is described in the form of graphs and tables.

APPLICATION BULLETIN 73
Low-cost Fiber Optic Transmitter and Receiver Interface Circuits

This bulletin provides assistance in designing circuits to interface Hewlett-Packard HFBR-0400 low-cost miniature fiber optic components with TTL I/O for applications at data rates up to 35 MBD. The TTL T_X/R_X circuits presented in this applications bulletin have been designed, built, and tested. They are suitable for a wide range of applications. The HFBR-0400 fiber optic components are compatible with either SMA or ST style connectors. The concepts illustrated in this bulletin are applicable to both types.

APPLICATION BULLETIN 74
Option 002 Tape and Reel LED Lamps

Hewlett-Packard Option 002 tape and reel LED lamps have straight leads on standard 2.54 mm (0.100 inch) center spacing. These lamps may be auto-inserted into printed circuit boards with most radial auto-insertion equipment. However, it is important to have the proper plated through hole size and spacing in the printed circuit to assure high insertion yields.

This application bulletin details the specific information on the printed board plated through hole size, spacing and tolerances necessary to assure high insertion yields of Option 002 LED lamps with 0.46 mm (0.018 inch) square leads.

APPLICATION BULLETIN 75
ESD Control in Portable Bar Code Readers

This application bulletin provides information to help the designer of portable bar code decoders to harden their system to ESD. (Electrostatic discharge)

APPLICATION BULLETIN 76
Use of LED Lamps and Displays in Night Vision Goggle Secure Lighting Applications

NVG secure lighting is concerned with the detectability of a light source on the ground by GEN II night vision goggles at some distance. The U.S. Army CECOM has issued a Secure Lighting Statement of Work, SOW, which details the lighting modification guidelines that may be incorporated to make various light sources NVG secure. The objective of the Secure Lighting Program (paraphrased) is "to render all combat nomenclatured items designated for use at Corps level and below less detectable to threat image intensifier night observation as far as is practical."

This application bulletin discusses the particulars of the U.S. Army NVG Secure Lighting SOW. High-performance green and yellow LED/NVG filter combinations that satisfy secure lighting requirements are discussed. Predicted performance values are presented in tabular format.

APPLICATION BULLETIN 77
Interfacing the Hewlett-Packard SmartWand

This application bulletin provides circuits to allow the user to interface the HP SmartWand to true RS232 connections.

APPLICATION NOTE 915
Threshold Detection of Visible and Infrared Radiation with PIN Photodiodes

PIN photodiodes are compared with multiplier phototubes in an 11-point summary of their relative merits. This is followed by a description of PIN photodiode device structure, mode of operation, and analysis of the diode's equivalent circuit.

Four pre-amplifier circuits are presented. Two of these describe use of operational amplifiers — one for linear response, the other for logarithmic response. The other two circuits are designed for substantially higher speeds of response, using discrete components to obtain wide bandwidth as well as high sensitivity.

APPLICATION NOTE 934
5082-7300 Series Solid State Display Installation Techniques

The 4N5X, HDSP-07XX/08XX/09XX, and 5082-73XX series Numeric/Hexadecimal indicators are an excellent solution to most standard display problems in commercial, industrial and military applications. The unit integrates the display character and associated drive electronics in a single package. This advantage allows for space, pin and labor cost reductions, at the same time improving overall reliability.

The information presented in this note describes general methods of incorporating this series into varied applications.

APPLICATION NOTE 945
Photometry of Red LEDs

Nearly all LEDs are used either as discrete indicator lamps or as elements of a segmented or dot-matrix display. As such, they are viewed directly by human viewers, so the primary criteria for determining their performance is the judgment of a viewer. Equipment for measuring LED light output should, therefore, simulate human vision.

Abstracts (cont.)

This application note will provide answers to these questions:

1. What to measure (definitions of terms)
2. How to measure it (apparatus arrangement)
3. Whose equipment to use (criteria for selection)

APPLICATION NOTE 947
Digital Data Transmission Using Optically Coupled Isolators

Optocouplers make ideal line receivers for digital data transmission applications. They are especially useful for elimination of common mode interference between two isolated data transmission systems. This application note describes design considerations and circuit techniques with special emphasis on selection of line drivers, transmission lines, and line receiver termination for optimum data rate and common mode rejection. Both resistive and active terminations are described in detail. Specific techniques are described for multiplexing applications, and for common mode rejection and data rate enhancement.

APPLICATION NOTE 948
Performance of the 6N135/6/7 Series of Optocouplers in Short to Moderate Length Digital Data Transmission Systems

Describes use of HP 6N135/6/7 optocouplers as line receivers in a TTL-TTL compatible NRZ (nonreturn-to-zero) data transmission link. It describes several useful total systems including line driver, cable, terminations, and TTL compatible connections.

APPLICATION NOTE 951-1
Applications for Low Input Current, High Gain Optocouplers

Optocouplers are useful in line receivers, logic isolation, power lines, medical equipment, and telephone lines. This note discusses use of the 6N138/9 series high CTR optocouplers in each of these areas.

APPLICATION NOTE 951-2
Linear Applications of Optocouplers

Although optocouplers are not inherently linear, the separate photodiodes used in Hewlett-Packard optocouplers provide better linearity as well as higher speed of response than phototransistor detectors.

Linearity enhancement by use of paired optocouplers is described with specific circuit examples offering DC-to-25 KHz response. These examples illustrate the relative merits of differential and servo techniques.

A circuit with linear AC response to 10 MHz is also described for analog optocouplers having the photodiode terminals externally accessible.

Digital techniques of voltage-to-frequency conversion and pulse width modulation are discussed. Their linearity is quite independent of optocoupler linearity but require use of high speed optocouplers for low distortion.

APPLICATION NOTE 1002
Consideration of CTR Variations in Optocoupler Circuit Designs

A persistent, and sometimes crucial, concern of designers using optocouplers is that of the current transfer ratio, CTR, changing with time. The change, or CTR degradation, must be accounted for if long, functional lifetime of a system is to be guaranteed. This application note will discuss a number of different sources for this degradation.

APPLICATION NOTE 1004
Threshold Sensing for Industrial Control Systems with the HCPL-3700 Interface Optocoupler

Interfacing from industrial control systems to logic systems is a necessary operation in order to monitor system progress. This interfacing is found in process control systems, programmable controllers, microprocessor subsystems which monitor limit and proximity switches, environmental sensors and ac line status; in switching power supplies for detection of ac power loss; in power back up systems which need an early warning of power loss in order to save special microprocessor memory information or switch to battery operation, etc. Applications of the HCPL-3700 interface optocoupler are addressed in this note. The isolation and threshold detection capability of the HCPL-3700 allows it to provide unique features which no other optocoupler can provide. Addressed in this note are the advantages of using this optocoupler for isolating systems as well as the device characteristics, dc/ac operational performance with and without filtering, simple calculations for setting desired thresholds, and four typical application examples for the HCPL-3700. Additional coverage is given to protection considerations for the optocoupler from the standpoint of power transients, thermal conditions, and electrical safety requirements of the industrial control environment.

APPLICATION NOTE 1005
Operational Considerations for LED Lamps and Display Devices

In the design of a display system, which incorporates LED lamps and display devices, the objective is to achieve an optimum between light output, power dissipation, reliability, and operating life. The performance characteristics and capabilities of each LED device must be known and understood so that an optimum design can be achieved. The primary source for this information is the LED device data sheet. The data sheet typically contains Electrical/Optical Characteristics that list the performance of the device and Absolute Maximum Ratings in conjunction with characteristic curves and other data which describe the capabilities of the device. A thorough understanding of this information and its intended use provides the basis for achieving an optimum design. This application note presents an in-depth discussion of the theory and use of the electrical and optical information contained

Abstracts (cont.)

within a data sheet. Two designs using this information in the form of numerical examples are presented, one for dc operation and one for pulsed (strobed) operation.

APPLICATION NOTE 1006
Seven Segment LED Display Applications

This application note begins with a detailed explanation of the two basic product lines that Hewlett-Packard offers in the seven segment display market. This discussion includes mechanical construction techniques, character heights, and typical areas of application. The two major display drive techniques, dc and strobed, are covered. The resultant tradeoffs of cost, power, and ease of use are discussed. This is followed by several typical instrument applications including counters, digital voltmeters, and microprocessor interface applications. Several different microprocessor based drive techniques are presented incorporating both the monolithic and the large seven segment LED displays.

The application note contains a discussion of intensity and color considerations made necessary if the devices are to be end stacked. Hewlett-Packard has made several advances in the area of sunlight viewability of LED displays. The basic theory is discussed and recommendations made for achieving viewability in direct sunlight. Information concerning display mounting, soldering, and cleaning is presented. Finally, an extensive set of tables has been compiled to aid the designer in choosing the correct hardware to match a particular application. These tables include seven segment decoder/drivers, digit drivers, LSI chips designed for use with LEDs, printed circuit board edge connectors, and filtering materials.

APPLICATION NOTE 1007
Bar Graph Array Applications

This application note begins with a description of the manufacturing process used to construct the 10 element array. Next is a discussion of the package design and basic electrical configuration and how they affect designing with the bar graph array. Mechanical information including pin spacing and wave soldering recommendations are made.

Display interface techniques of two basic types are thoroughly discussed. The first of these two drive schemes is applicable in systems requiring display of analog signals in a bar graph format. The second major drive technique interfaces bar graph arrays in systems where the data is of a digital nature. Examples of microprocessor controlled bar graph arrays are presented.

Summarized for the design engineer are tables of available integrated circuits for use with bar graph arrays. Finally, a list of recommended filters is included.

APPLICATION NOTE 1008
Optical Sensing with the HBCS-1100

This application note gives the basic optical flux coupling design for discrete emitters and detectors. Presents the concepts of modulation transfer function, depth of field, and reflective sensor design. It also discusses the optical and electrical operation of the HBCS-1100 High Resolution optical sensor. Finally, it presents electrical design techniques which allow the HBCS-1100 to interface with popular logic families.

APPLICATION NOTE 1011
Design and Operational Considerations for the HEDS-5000 Incremental Shaft Encoder

This application note is directed toward the system designer using the HEDS-5000 and HEDS-6000 modular incremental shaft encoders. First the note briefly analyzes the theory of design and operation of the HEDS-5000 and HEDS-6000. A practical approach to design considerations and an error analysis provide an indepth treatment of the relationship between motor mechanical parameters and encoding error accumulation. Several design examples demonstrate the analysis techniques presented. Operation considerations for assembly, test, trouble shooting and repair are presented. Finally some circuits and software concepts are introduced which will be useful in interfacing the shaft encoder to a digital or microprocessor based system. Appendix A summarizes the uses and advantages of various encoder technologies while Appendix B provides guidance for selecting DC motors suitable for use with the HEDS-5000 and HEDS-6000.

APPLICATION NOTE 1012
Methods of Legend Fabrication

Hewlett-Packard LED Light Bar Modules inscribed with fixed messages or symbols can be used as economical annunciators. Annunciators are often used in front panels to convey the status of a system, to indicate a selected mode of operation or to indicate the next step in a sequence. This application note discusses alternative ways the message or symbols (legends) can be designed. A selection matrix is provided to assist in the selection of the most appropriate method of legend fabrication. Each fabrication method is explained in detail along with mounting and attachment techniques. Finally, prevention of cross-talk is discussed for legend areas of a multi-segmented light bar.

APPLICATION NOTE 1013
Elements of a Bar Code System

This application note describes in detail the elements that make up most bar code systems. Included is a discussion of the fundamental system design, detailed discussion of 7 popular code symbologies, a section on symbol generation, and methods of data entry. A glossary of terms and a reference section are also included. This is an excellent publication for people who are just learning about bar code, or for those who need a more comprehensive understanding of the subject.

APPLICATION NOTE 1015
Contrast Enhancement Techniques for LED Displays

Contrast enhancement is essential to assure readability of LED displays in a variety of indoor and outdoor

Abstracts (cont.)

ambients. Plastic filters are typically used for contrast enhancement with indoor lighting and glass circular polarized filters are typically used to achieve readability in sunlight ambients.

This application note discusses contrast enhancement technology for both indoor and outdoor ambients, the theory of Discrimination Index and provides a list of tested contrast enhancement filters and filter manufacturers.

APPLICATION NOTE 1016
Using the HDSP-2000 Alphanumeric Display Family

The HDSP-2000 family of alphanumeric display products provides the designer with a variety of easy-to-use display modules with on board integrated circuit drivers. The HDSP-2000 family has been expanded to provide three display sizes with character heights ranging from 3.8 mm (0.15") to 6.9 mm (0.27"), four display colors, and both commercial and military versions. These displays can be arranged to create both single line and multiple line alphanumeric panels.

This note is intended to serve as a design and application guide for users of the HDSP-2000 family of alphanumeric display devices. It covers the theory of the device design and operation, considerations for specific circuit designs, thermal management, power derating and heat sinking, and intensity modulation techniques.

APPLICATION NOTE 1017
LED Solid State Reliability

Light emitting diode display technology offers many attractive features including multiple display colors, sunlight readability, and a continuously variable intensity adjustment. One of the most common reasons that LED displays are designed into an application, however, is the high level of reliability of the LED display. Hewlett-Packard has taken a leadership role in setting reliability standards for LED displays and documenting reliability performance.

This note explains how to use the reliability data sheets published for HP LED indicators and displays. It describes the LED indicator and display packages, defines device failures, and discusses parameters affecting useful life, failure rates and mechanical test performance.

APPLICATION NOTE 1018
Designing with the HCPL-4100 and HCPL-4200 Current Loop Optocoupler

Digital current loops provide unique advantages of large noise immunity and long distance communication at low cost. Applications are wide and varied for current loops, but one of the critical concerns of a loop system is to provide a predictable, reliable and isolated interface with the loop. The HCPL-4100 (transmitter) and HCPL-4200 (receiver) optocouplers provide for easy interfacing to and from a current loop with minimal design effort. Within this application note a complete description of the HCPL-4100/4200 devices is given along with applications for digital, 20 mA, simplex, half duplex and full duplex loops. These loops can be either point-to-point or multidrop configurations. Factors which affect data performance are discussed. Circuit arrangements with specific data performance are given in graphical and tabular form.

APPLICATION NOTE 1019
Using the HLMP-4700/-1700/-7000 Series Low Current Lamps

Hewlett-Packard manufactures a series of LED lamps that are designed for operation at 2 mA DC. These lamps are available in high efficiency red, yellow, and high performance green in a variety of package styles. These lamps allow the designer to reduce system power dissipation, and drive circuit costs.

This application note contrasts electrical characteristics of the low-current lamp with HP's conventional lamp. Costs of implementing lamp drive circuits are discussed, as in power conservation in TTL and circuits involving higher voltages. Finally, telecommunications and battery information are presented.

APPLICATION NOTE 1021
Utilizing LED Lamps Packaged on Tape and Reel

Hewlett-Packard offers many of its LED lamps packaged on tape and reel for radial insertion by automatic equipment during high volume production of PC board assemblies.

This application note is a guide to the use of tape and reel LED lamps in the automatic insertion process. Discussed are the LED lamp tape and reel configuration, the radial lead insertion process, PC board design considerations, a method to maintain LED lamp alignment during soldering and lamp stand-off height information.

APPLICATION NOTE 1022
High Speed Fiber Optic Link Design with Discrete Components

As the technology of fiber optic communication matures, design considerations for large volume applications focus as much on cost and reliability, as bandwidth and bit-error-rate. This application note describes a 100 MBd fiber optic communication link which was implemented with low-cost, non-exotic technology, including LED transmitter, PIN photodiode detector, off-the-shelf ICs and discrete components, laid out on epoxy-glass circuit boards.

APPLICATION NOTE 1023
Radiation Immunity of Hewlett-Packard Optocouplers

Opening with a quotation from MIL-HDBK-279 describing optocouplers containing photodiodes as superior to optocouplers containing phototransistors, the text describes the properties of ionizing radiation (particles and photons) and how it affects the performance of optocouplers. Graphs show degradation of CTR (Current Transfer Ratio) in the 6N140 as a function of gamma total dose (up to 1000

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rad [Si] and as a function of total neutron fluence (up to 6×10^{12} n/cm^2). A table gives radiation hardness requirements for various military requirements.

APPLICATION NOTE 1024
Ring Detection with the HCPL-3700 Optocoupler

With the increased use of modems, automatic phone answering equipment, private automatic branch exchange (PABX) systems, etc., low-cost, reliable, isolated ring detection becomes important to many electronic equipment manufacturers. This application note addresses the definition of ringing requirements (U.S.A. and Europe), applications of the HCPL-3700 optocoupler as a simple, but effective, ring detector. A design example is shown with calculations to illustrate proper use of the HCPL-3700. Features which are integrated into the HCPL-3700 provide for predictable detection, protection and isolation when compared to other optocoupler techniques.

APPLICATION NOTE 1025
Applications and Circuit Design for the HEDS-7500 series Digital Potentiometer

This application note demonstrates some of the uses for the Hewlett-Packard HEDS-7500 series digital potentiometer, explains how a digital potentiometer works, and explains some of the advantages of a digital potentiometer over a standard resistive potentiometer. In addition, this application note provides some examples of circuitry which will interface the digital potentiometer to a microprocessor, and provides mechanical design considerations and available options for the HEDS-7500 series digital potentiometer.

APPLICATION NOTE 1026
Designing with Hewlett-Packard's Smart Display — The HPDL-2416

The trend in LED Alphanumeric displays is to simplifiy a designer's job as much as possible by incorporating on board character storage, ASCII character generation, and multiplexing within the display. The HPDL-2416 is a four character alphanumeric display which incorporates a 64 character ASCII decoder and an on board CMOS IC to perform these functions. This application note is intended to serve as a design and application guide for users of the HPDL-2416. The information presented will cover: electrical description, electrical design considerations, interfacing to micro-processors, pre-programmed message systems, mechanical and electrical handling, and contrast enhancement.

APPLICATION NOTE 1027
Soldering LED Components

The modern printed circuit board is assembled with a wide variety of semiconductor components. These components may include LED lamps and displays in combination with other components. The quantity of solder connections will be many times the component count. Therefore, the solder connections must be good on the first pass through the soldering process. The effectiveness of the soldering process is a function of the care and attention paid to the details of the process. It is important for display system designers and PC board assembly engineers to understand the aspects of the soldering process and how they relate to LED components to assure high yields.

This application note provides an in depth discussion on the aspects of the soldering process and how they relate to LED lamps and display components, with the objective of being to serve as a guide towards achieving high yields for solder connections.

APPLICATION NOTE 1028
Surface Mount Subminiature LED Lamps

Modern printed circuit boards are being assembled with surface mounted components, replacing through hole mounted components in many traditional applications. Hewlett-Packard has surface mount options for its HLMP-6000/7000 series of subminiature LED lamps, Options 011 and 013 for "gull wing" leads and Option 021 for "yoke" leads for inverted mounting.

This application note provides information on how to surface mount and vapor phase reflow solder these surface mount subminiature LED lamps.

APPLICATION NOTE 1029
Luminous Contrast and Sunlight Readability of the HDSP-238X Series LED Alphanumeric Displays for Military Applications

Military specifications for avionics and other kinds of electronics that require readability in sunlight use specific definitions for luminous contrast. The concept of chrominance contrast and the theory of Discrimination Index (see Hewlett-Packard Application Note 1015) are not used by the military as a means of determining readability in sunlight. Thus, the military requirements for readability in sunlight are based solely on luminous contrast measurements. This application note discusses the luminous contrasts used by military specifications, describes anti-reflection/circular polarized filters designed for use with the HDSP-238X series sunlight viewable LED displays and presents luminous contrast data for various HDSP-238X display/filter combinations.

APPLICATION NOTE 1031
Front Panel Design

In many applications designers are faced with the problem of how to match the perceived brightness of an assortment of seven segment displays, light bars, linear arrays, and lamps on the same front panel. To simplify this problem Hewlett-Packard has introduced S02 option selected parts. S02 option selected parts provide a restricted range of luminous intensity for a given part number. This application note is written as a design guide to matching the perceived brightness of LED displays and lamps on a front panel. The procedure shown in the application note will enable the designer to calculate the needed display drive currents (either dc or pulsed) for a given ambient light level and specified filter. Two techniques are explained. The first is how to

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calculate the drive currents to insure minimum acceptable brightness. The second is how to calculate the drive currents to match the display on the front panel to a known display.

APPLICATION NOTE 1032
Design of the HCTL-1000's Digital Filter Parameters by the Combination Method

Digital closed loop motion control systems employing a dedicated IC as a controller are becoming increasingly popular as a solution to the need for controlled velocity and positioning systems. Hewlett-Packard's HCTL-1000 is a general purpose motion control IC which has been designed for this type of closed loop systems. A digital compensator has been designed into the HCTL-1000 to provide a stable response to an input command. This application note explains how the combination method can be used for calculation of the HCTL-1000's digital compensation filter parameters to provide a stable, closed loop position control system.

APPLICATION NOTE 1033
Designing with the HDSP-211X Smart Display Family

Hewlett-Packard's smart alphanumeric display, the HDSP-211X, is built to simplify the user's display design. Each HDSP-211X has an onboard CMOS IC which displays eight characters. All of the IC features are software driven. These features include 128 character ASCII decoder, 16 user-defined symbols, seven brightness levels, flashing characters, a self test, and all of the circuitry needed to decode, drive, and refresh eight 5 x 7 dot matrix characters.

This application note discusses how to interface the HDSP-211X display to either a Motorola 6808 or an Intel 8085 microprocessor. A 32 character display interface is explained for each microprocessor. The note includes a detailed description of the hardware and software. The software illustrates how the user-defined symbols and a string of ASCII characters are loaded into the display.

TECHNICAL BRIEF 101
Fiber Optic SMA Connector Technology

Technical Brief 101 discusses tradeoffs between various SMA connector techniques and provides a contact matrix of manufacturers versus SMA connector type.

TECHNICAL BRIEF 102
Fiber/Cable Selection for LED Based Local Communications Systems

Technical Brief 102 is intended to assist the first time user of fiber optics with the selection of a fiber cable that best meets desired system requirements. Issues discussed in Technical Brief 102 include: Tradeoffs between various fiber types, the effect of LED emitters on fiber performance, coupled power versus numerical aperture and factors that influence cable selection. A contact matrix that lists fiber cable manufacturers versus cable type is also included.

TECHNICAL BRIEF 103
High Speed Optocouplers vs. Pulse Transformers

For high speed signaling with ground loop isolation, pulse transformers are often used. Here are summarized briefly the difficulties encountered in the use of pulse transformers, such as rise-time, sag, and interwinding capacitance. A table summarizes the parameters of Hewlett-Packard optocouplers designed for high speed signaling. A second table summarizes the advantages of using these optocouplers instead of pulse transformers.

TECHNICAL BRIEF 104
Baseband Video Transmission with Low Cost Fiber Optic Components

The transmission of video signals over fiber-optic links offers several advantages relative to comparable wire distribution systems. Technical Brief 104 describes simple T_X/R_X circuits providing 20 MHz, 3 dB bandwidth for high resolution analog video transmission.

TECHNICAL BRIEF 105
ST Connector/Cable Guide

A fairly recent development, by AT&T, is the ST* Connector, and its rapid acceptance by users of fiber optic components is an indication that it may soon become a standard connector.

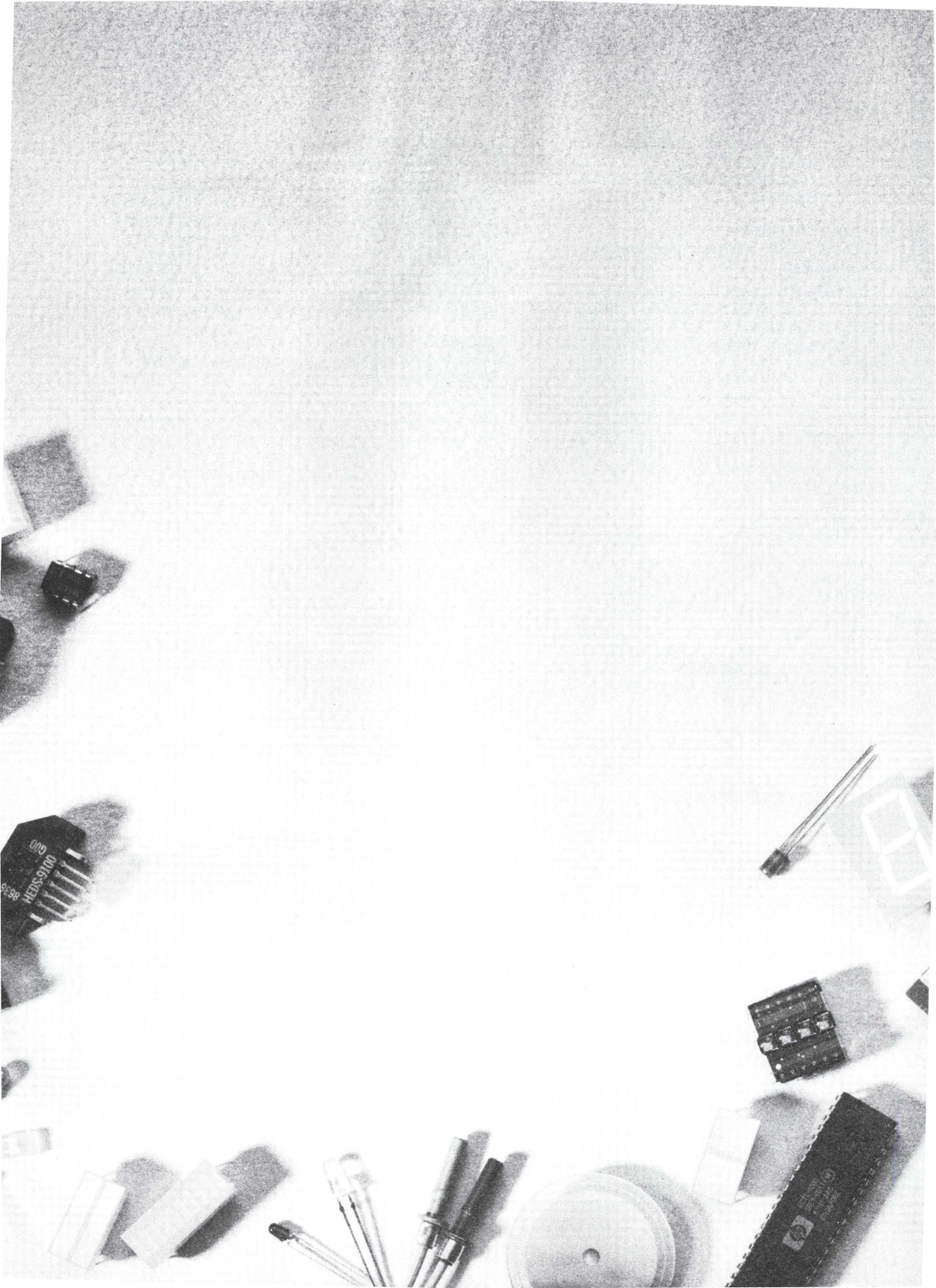
Technical Brief 105 provides a quick comparison between the SMA and the ST style connector. A table at the end lists some suppliers of the ST style connectored cables.

*ST is a registered trademark of AT&T Lightguide Cable Connectors.

INK-JET DESIGNER'S GUIDE

This Designer's Guide is intended to supplement the print cartridge data sheet by providing technical assistance in the design and operation of any printing device using the Thermal Ink-jet print cartridge. To this end, it will:

- provide a basic understanding of the print cartridge operation
- identify the key design parameters affecting printing performance
- suggest methods for optimizing or enhancing performance
- identify the primary failure modes and limitations of the print cartridge
- provide guidelines for maintenance and troubleshooting of the print cartridge



Appendix

- **HP Components Authorized Distributor and Representative Directory**
- **HP International Sales and Service Offices**
- **HP Components U.S. Sales and Service Offices**

HP Components Authorized Distributor and Representative Directory

United States

Alabama

Hall-Mark Electronics
4900 Bradford Drive
Huntsville 35807
(205) 837-8700

Hamilton/Avnet
4940 Research Drive N.W.
Huntsville 35805
(205) 837-7210

Schweber Electronics
4910 Corporate Drive, Suite J
Huntsville 35805
(205) 895-0480

Arizona

Hamilton/Avnet
30 S. McKemy Avenue
Chandler 85226
(602) 961-6400

Schweber Electronics
11049 N. 23rd. Drive
Suite 100
Phoenix 85029
(602) 997-4874

California

Avnet Electronics
350 McCormick Avenue
Costa Mesa 92626
(714) 754-6100

Hall-Mark Electronics
8130 Remmet Avenue
Canoga Park 91304
(818) 716-7300

Hall-Mark Electronics
6341 Auburn Blvd., Suite D
Citrus Heights 95610
(916) 722-8600

Hall-Mark Electronics
19220 S. Normandie
Torrance 90502
(213) 217-8400

Hall-Mark Electronics
1110 Ringwood Court
San Jose 95131
(408) 432-0900

Hall-Mark Electronics
14831 Franklin Avenue
Tustin 92680
(714) 669-4100

Hamilton/Avnet
9650 De Soto Avenue
Chatsworth 91311
(818) 700-6565

California (cont.)

Hamilton/Avnet
Southwest Regional
Stocking Center
350 McCormick Avenue
Costa Mesa, CA 92626
(714) 754-6100

Hamilton/Avnet (Corp)
10950 W. Washington Blvd.
Culver City 90230
(213) 558-2020

Hamilton/Avnet
3002 East G Street
Ontario 91764
(714) 989-4602

Hamilton/Avnet
4103 Northgate Blvd.
Sacramento 95834
(916) 925-2216

Hamilton/Avnet
4545 Viewridge Avenue
San Diego 92123
(619) 571-7510

Hamilton/Avnet
1175 Bordeaux Drive
Sunnyvale 94086
(408) 743-3300

Hamilton Electro Sales
3170 Pullman Street
Costa Mesa 92626
(714) 641-4199

Hamilton/Avnet
1361 "B" West 190th Street
Gardena 90248
(213) 217-6700

Schweber Electronics
21139 Victory Blvd.
Canoga Park 91303
(818) 999-4702

Schweber Electronics
371 Van Ness Way
Suite 100
Torrance 90501
(213) 320-8090

Schweber Electronics
17822 Gillette Avenue
Irvine 92714
(714) 863-0200

Schweber Electronics
1771 Tribute Road
Suite B
Sacramento 95815
(916) 929-9732

Schweber Electronics
6750 Nancy Ridge Drive
Bldg. 7, Suites D & E
San Diego 92121
(619) 450-0454

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90 East Tasman Drive
San Jose 95134
(408) 432-7171

Colorado

Hamilton/Avnet
8765 East Orchard
Suite 708
Englewood 80111
(303) 740-1000

Schweber Electronics
8955 E. Nichols Avenue
Suite 200
Englewood 80112
(303) 799-0258

Connecticut

Hall-Mark Electronics
Barnes Industrial Park
33 Village Lane
P.O. Box 5024
Wallingford 06492
(203) 269-0100

Hamilton/Avnet
Commerce Drive
Commerce Industrial Park
Danbury 06810
(203) 797-2800

Schweber Electronics
Finance Drive
Commerce Industrial Park
Danbury 06810
(203) 748-7080

Florida

Hall-Mark Electronics
15301 Roosevelt Blvd.
Suite 303
Clearwater 33520
(813) 530-4543

Hall-Mark Electronics
7648 Southland Blvd.
Suite 100
Orlando 32809
(305) 855-4020

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3161 S.W. 15th Street
Pompano Beach 33069-4800
(305) 971-9280

Hamilton/Avnet
6801 N.W. 15th Way
Ft. Lauderdale 33309
(305) 971-2900

Hamilton/Avnet
3197 Tech Drive North
St. Petersburg 33702
(813) 576-3930

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6947 University Blvd.
Winter Park 32792
(305) 628-3888

Schweber Electronics
317 S. North Lake Blvd.
Suite 1024
Altamonte Springs 31701
(305) 331-7555

Schweber Electronics
3665 Park Central Blvd. North
Building #6
Pompano Beach 33064
(305) 977-7511

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6410 Atlantic Boulevard
Suite 115
Norcross 30071
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Hamilton/Avnet
5825 D. Peachtree Corners East
Norcross 30092
(404) 447-7500

Schweber Electronics
303 Research Drive
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Norcross 30092
(404) 446-5842

Illinois

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210 Mittel Drive
Wooddale 60191
(312) 860-3800

Hamilton/Avnet
1130 Thorndale Avenue
Bensenville 60106
(312) 860-7700

Schweber Electronics
904 Cambridge Drive
Elk Grove Village 60007
(312) 364-3750

Indiana

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4275 W. 96th Street
Indianapolis 46268
(317) 872-8875

Hamilton/Avnet
485 Gradle Drive
Carmel 46032
(317) 844-9333

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915 33rd Avenue S.W.
Cedar Rapids 52404
(319) 362-4757

Schweber Electronics
5270 North Park Place N.E.
Cedar Rapids 52402
(319) 373-1417

Kansas

Hall-Mark Electronics
10809 Lakeview Drive
Lenexa 66215
(913) 888-4747

Hamilton/Avnet
9219 Quivira Road
Overland Park 66215
(913) 888-8900

Schweber Electronics
10300 W. 103rd. Street
Suite 200
Overland Park 66214
(913) 492-2922

Maryland

Hall-Mark Electronics
10240 Old Columbia Road
Columbia 21046
(301) 988-9800

Hamilton/Avnet
6822 Oak Hall Lane
Columbia 21045
(301) 995-3500

Schweber Electronics
9330 Gaither Road
Gaithersburg 20877
(301) 840-5900

Massachusetts

Hall-Mark Electronics
6 Cook Street
Pinehurst Park
Billerica 01521
(617) 935-9777

Hamilton/Avnet
10D Centennial Drive
Peabody 01960
(617) 531-7430

Schweber Electronics
25 Wiggins Avenue
Bedford 01730
(617) 275-5100

Michigan

Hamilton/Avnet
2215 29th Street S.E.
Grand Rapids 49508
(616) 243-8805

Hamilton/Avnet
32487 Schoolcraft Road
Livonia 48150
(313) 522-4700

Schweber Electronics
12060 Hubbard Drive
Livonia 48150
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Minnesota

Hall-Mark Electronics
10300 Valley View Road
Suite 101
Eden Prairie 55344
(612) 941-2600

Hamilton/Avnet
12400 Whitewater Road
Minnetonka 55343
(612) 932-0600

Schweber Electronics
7424 W. 78th Street
Edina 55435
(612) 941-5280

Missouri

Hall-Mark Electronics
13750 Shoreline Drive
Earth City 63045
(314) 291-5350

Hamilton/Avnet
13743 Shoreline Court
Earth City 63045
(314) 344-1200

Schweber Electronics
502 Earth City Expwy.
Suite 203
Earth City, 63045
(314) 739-0526

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444 East Industrial Park Dr.
Manchester 03103
(603) 624-9400

Schweber Electronics
Bedford Farms, Bldg. 2
Kilton & South River Road
Manchester 03102
(603) 625-2250

New Jersey

Hall-Mark Electronics
107 Fairfield Road
Suite 1B
Fairfield 07006
(201) 575-4415

Hall-Mark Electronics
1000 Midlantic Drive
Mt. Laurel 08054
(609) 235-1900

Hamilton/Avnet
1 Keystone Avenue, Bldg 36
Cherry Hill 08003
(609) 424-0118

Hamilton/Avnet
10 Industrial Road
Fairfield 07006
(201) 575-3390

Schweber Electronics
18 Madison Road
Fairfield 07006
(201) 227-7880

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2524 Baylor S.E.
Albuquerque 87106
(505) 765-1500

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101 Comac Street
Ronkonkoma 11779
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Hamilton/Avnet
933 Motor Park Way
Hauppauge 11788
(516) 434-7421

Hamilton/Avnet
2060 Town Line Road
Rochester 14623
(716) 475-9130

Hamilton/Avnet
103 Twin Oaks Drive
Syracuse 13206
(315) 437-2641

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3 Town Line Circle
Rochester 14623
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Jericho Turnpike, CB 1032
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Printed in U.S.A. Data Subject to Change Revised from 5954-8412 5954-8450 (12/87)

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